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CORRECTIONS

Volume 65, March 1937, page 105, 2d column, the portion of the text beginning "This zone of icing * * *" and ending with "air streams passing over them." (four paragraphs in all) should be inserted after the 2d paragraph of column 1 on page 104. Same review, page 121, "Late Reports", table 3, 5th column of figures, "811.2" should be "11.2."

April 1937, page 170, in the section "*Ohio Valley and Tennessee*", the number of partly cloudy days at Lexington printed as "16" should be "6"; page 184, Hancock crest, "25.8" should be "25.7".

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MONTHLY WEATHER REVIEW

Editor, EDGAR W. WOOLARD

VOL. 65, NO. 5
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MAY 1937

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CLIMATIC CYCLES IN EASTERN OREGON AS INDICATED BY TREE RINGS[1]

By F. P. KEEN

[Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, May 1937].

During the past two decades the ponderosa pine forests of eastern Oregon and northeastern California have been seriously depleted by drought and bark beetles. Billions of board feet of merchantable timber have been killed, and there has been a gradual encroachment of desert conditions into what were once thriving pine stands.

The question naturally arose in the minds of foresters and timber owners as to whether this trend toward dryness and retreat of the forest was to continue over any long period of time or was merely a short cycle in a variable climate which would soon reverse the trend and give some hope for forest perpetuation in threatened sites. Since this problem was intimately tied in with increasing timber mortality due to bark beetle activity, we, as entomologists, were concerned to know whether we could expect any eventual aid from Nature in holding beetle damage in check.

Weather records, because of the relatively short period of time covered by them, were obviously inadequate to give an answer as to long-period climatic fluctuations. Records as to fluctuations in lake levels were also either too recent or too indefinite as to dates to be of much help. Tree rings, on the other hand, carried a very old and precise record of climatic fluctuations, provided they could be interpreted.

EARLY WORK ON CLIMATE AND TREE GROWTH

The influence of climate on tree growth has been recognized by scientists for centuries. Even Leonardo Da Vinci realized this relationship when, in the fifteenth century, he explained to his pupil "how to arrive at the years of a split tree trunk by the number of its rings; and by the thickness of these rings, at the degree of moisture of the corresponding year."

In more recent times, Huntington (7), (8), Antevs (1), Douglass (3), (4), and many others have contributed to our knowledge of this subject and have demonstrated that tree rings not only show the age of a tree but record all of the vicissitudes throughout its life. Particularly prominent in the tree-ring record are such events as severe forest fires, insect defoliations, and droughts. The ancient history thus recorded gives a particularly valuable record of long-period climatic sequences, provided the other influences which have affected growth can be eliminated.

Recently the Library of the Forest Service, United States Department of Agriculture, in Washington, D. C., issued a 7-page leaflet in which the present tree-ring bibliography was compiled (12). The subject is, therefore, not a new one but has become well established as a method of analyzing ancient climatic history.

The only new phase of the present study is the application of the tree-ring method of analysis to the interpretation of growth and climatic cycles in eastern Oregon. The only previous work of this character in the Pacific Northwest is that reported by Robert Marshall (9) in the vicinity of Priest River, Idaho, and a general analysis of growth cycles by Walter H. Meyer (10). Douglass (4) has also reported the analysis of a few tree-ring samples from this region.

METHODS OF STUDY

The present study was begun in 1923 at Klamath Falls, Oreg., and has been continued somewhat intermittently ever since. Only in the last few years, however, has it been possible to give it sufficient attention to bring definite results. During the last year, the assistance of two W. P. A. helpers loaned by the Pacific Northwest Forest Experiment Station has materially aided me in completing measurements and computations. Measuring by micrometer hundreds of trees involving thousands of rings has been a very tedious and laborious process, and I am gratefully indebted to a number of assistants who have strained their eyesight over this phase of the work.

The methodology of tree-ring studies such as the present one has been very fully described by Huntington (7), Antevs (1), and Douglass (3), and does not need to be discussed here except to indicate briefly such variations as were made in these methods for certain steps.

Tree selection.—Since we were most concerned with bark beetle damage to ponderosa pine (*Pinus ponderosa*) in eastern Oregon, it was only natural that this tree should have been selected for the tree-ring study. Moreover, it is a tree admirably adapted to this purpose, and is the one first selected by Douglass (3) for his comprehensive tree-ring studies in the Southwest.

In the ponderosa pine stands of eastern Oregon, moisture is a limiting factor in tree growth. Given adequate soil moisture and suitable temperatures, ponderosa pine makes rapid annual growth. When soil moisture drops below the wilting coefficient, the tree suffers; foliage is lost, roots dry up, and diameter growth diminishes, sometimes almost to the vanishing point. Following severe droughts, once adequate moisture conditions are restored, it may take several years for trees to recuperate. Ring width thus tends to measure more or less the cumulative effect of moisture deficiency. Such a study would not be possible in western Oregon and Washington, where moisture is rarely, if ever, a limiting factor in tree growth. A few comparisons of the rings of Douglas fir from western Oregon showed such uniformity in growth as to indicate clearly the difficulties involved in using a humid-zone tree for a climatic study.

[1] This paper is a preliminary report on a study not yet completed, the results of which will probably be given in more detail in a later publication. It was presented at the Meeting of the American Meteorological Society held at Seattle, Wash. July 17, 1936.

In the first selection of trees for ring study, only those growing on well-drained slopes were chosen. A brief analysis was sufficient to show that the ring patterns of trees growing along swales or creeks or on rocky ridges were not suitable for climatic comparisons. Those along streams were growing at a fairly uniform rate and only showed fluctuation in the very driest years. Trees growing on very rocky ridges were likely to be stunted and of such slow growth as to give very inconsistent patterns.

In the course of the study, tree-ring sections have been taken from 1,240 ponderosa pines in 44 different localities of eastern Oregon and northeastern California, and on different pine sites ranging from site III (stands in which trees reach an average height of 142 feet) to poor site VI along the desert edge (stands in which the average height of trees is 64 feet). A comparison of the growth fluctuations on different sites showed that the poor sites along the desert edge were much more sensitive to drought conditions than the moister sites at higher elevations. On these moister sites, tree growth was likely to be complacent except in very dry years. Trees growing on the desert edge, however, showed marked fluctuations from year to year and hence were best adapted for the tree-ring study.

From most plots a radial section or increment core was secured by means of a Swedish increment borer. For this purpose dominant trees between the ages of 100 and 250 years were selected. Trees of these ages are making fairly rapid diameter growth and respond readily to climatic changes. They give ring patterns which are easily measured and compared for the purpose of determining short, recent-period fluctuations. From 12 to 15 cores of this type were taken at random from each plot and 10 of the more uniform ones were selected for measurements. It was found that 10 cores, selected in this manner, gave a pattern of ring-growth fluctuations which represented with considerable accuracy the average ring pattern for that plot—a pattern which could be duplicated by any other random sample similarly taken.

For the long-period fluctuations, five areas were selected in widely separated sections of eastern Oregon, where logging operations were in progress. These were the Clover Station area west of Klamath Falls, the Bly Mountain area south of Beatty, the Horsefly Mountain area south of Bly, the Pringle Falls area west of La Pine, and the Watkins Butte area north of Fort Rock, Oreg. The first three areas in Klamath County were approximately 50 miles apart, while the last two areas in Deschutes County were over 100 miles north of these and 50 miles from each other. The differences in topography, forest type, site, and distance apart of these five areas served to eliminate the chance of any one factor other than climate affecting growth patterns in exactly the same manner in any given period of years.

From each area V-shaped radial sections were sawed from freshly cut stumps so as to include the center and the most uniform radius. From 30 to 90 stump sections were obtained from each area, so selected as to give a balanced overlapping of age classes.

From the Clover Station area a group of 31 stump sections from trees of various ages was obtained from the Weyerhaeuser Timber Co.'s logging operation. The timber was of Site quality III, and the oldest tree was 530 years of age. It was possible with this group to carry the record back to the year 1500, but satisfactory cross identification was not established beyond 1700.

From the Horsefly Mountain area a group of 46 stump sections was taken on the Pelican Bay Lumber Co.'s operation. The stand was of Site quality III and showed the same average growth rate as the Clover Station group. The oldest tree was 710 years of age and the record was carried back to 1500, but, as with the Clover Station group, there were too few trees in the older age groups to establish satisfactory cross identification beyond 1700.

The Bly Mountain group of 52 stump sections was obtained on the Crater Lake Lumber Co.'s operation south of Beatty, Oreg. The area represented a Site V stand, with a marked fluctuation in growth pattern between good and poor years. The oldest tree was 600 years of age and the pattern was carried back to the year 1480 with fairly satisfactory across identification.

The Pringle Falls group consisted of 46 stump sections taken adjacent to the Pringle Falls Experimental Forest near La Pine, Oreg., in the logging operation of the Shevlin-Hixon Lumber Co. The stand was a good Site IV, and the growth rate was quite uniform. Apparently, climatic changes had affected this stand only slightly and only the outstandingly poor years were marked in the pattern. However, the group showed an interesting history of fires and insect defoliations which caused cessation of growth at periodic intervals.

The Watkins Butte group consisted of 90 stump sections taken on the Brooks-Scanlon Lumber Co.'s operation on the edge of the desert north of Fort Rock, Oreg. This was the most complete group with a uniform overlapping of age classes throughout and a record going back to the year 1268. The oldest tree was approximately 755 years of age with about 100 years of growth missing at the center, due to decay. With a great deal of painstaking work, cross identification was accurately established throughout a full 650 years. This was difficult to do, as many of the samples showed missing rings, following years that were evidently those of severe defoliation. A few distant trees, less severely affected and having a full complement of rings, served to bridge the gaps and establish accurate dating.

Cross identification.—The first task, after reaching the laboratory, was to cross identify and accurately date the rings on each core. This was done by counting back from the outer ring of known date and, at the same time, matching the pattern with other cores from the same locality to avoid mistakes in the count. The sequence of small and large rings is usually so uniform for any one locality that there is no difficulty in deciding as to the correct year for any given ring, once the typical pattern has been determined. Figure 1 shows how closely two cores from the Watkins Butte area match for certain key years.

Because of fires, insect defoliations, frosts, and other injuries, the possibility of finding false rings or missing rings in the growth pattern of individual trees had to be considered. False rings were extremely rare, but missing rings were not uncommon, especially following abrupt stoppages of growth. Matching patterns before and after such catastrophes showed how many years were missing. In very few cores were more than one to three rings lost at such times. The pattern on each area was in this way independently determined, and then compared with the pattern of other areas. Since, as will be presently shown, there was found to be general agreement in key years between all areas, it seems reasonable to conclude that the dating was accurately done.

Measurements.—A smooth radial section was prepared on each core with a razor blade, and once the correct dates had been determined, the decadal intervals were marked on each core with indelible pencil.

Decadal measurements then were made to the nearest one-tenth millimeter with a millimeter rule. Measurements of annual growth were made with a microscope and

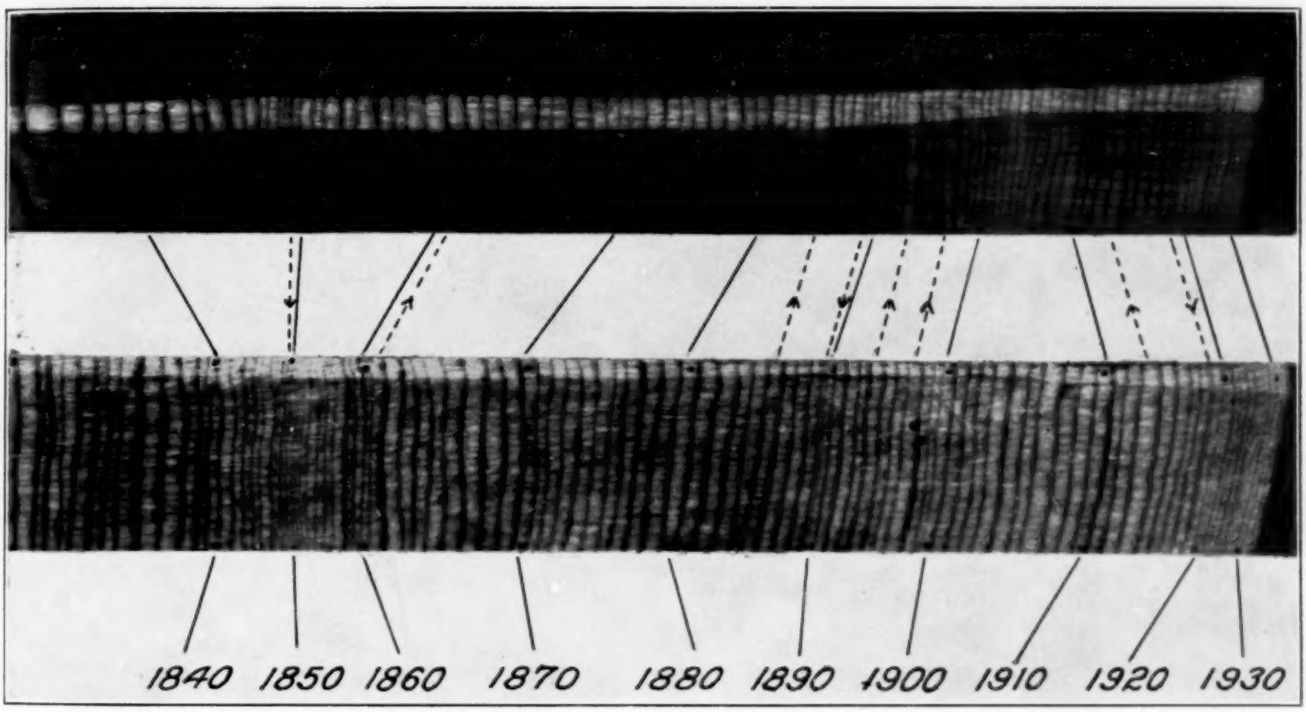


FIGURE 1.—Radial sections from two trees on the Watkins Butte area illustrating cross identification of ring patterns. Dotted lines connect certain key years which show consistently large or small growth and which have been useful for cross identification purposes.

sliding micrometer stage which recorded ring width to the nearest one-hundredth millimeter. This increment core measuring device was constructed in the Washington shops of the Bureau of Standards. A more complicated device has recently been constructed for the T. V. A., and is called a dendroheliomicrometer.

Plotting.—Decadal measurements were plotted on a fairly large scale so as to permit fitting through the points a smoothed average growth-trend curve from which values for normal growth could be read. Measurements of the annual rings were recorded and plotted on long, narrow strips of profile paper mounted on cardboard so that they could be shifted to provide for totalling by either age of tree or year dates.

THE GROWTH PATTERN

One of the first things noted about ponderosa pine growth in eastern Oregon was the similarity in fluctuations of annual growth, not only as between neighboring trees but also between trees throughout a wide area. This similarity in pattern gave encouragement to the theory that no factor other than climate could cause such a widespread and consistent response. Practically every increment core or radial section, wherever taken in eastern Oregon, showed a sudden drop in growth between the 1916 and 1917 rings; the years 1921, 1923, and 1928 stood out above their neighbors; and the years 1924 and 1929 showed the smallest growth in that decade.

Even when trees of different growth and vigor characteristics were compared, this same pattern of relative fluctuations was found. Figure 2 shows the annual radial growth by tree classes from one local area of the Ochoco National Forest. The actual millimeter growth of these different tree classes is vastly different in amount, as one would naturally expect when comparing young, vigorous trees with old, overmature veterans. But when this growth is reduced to a percentage of the general average for each class, then it is apparent that the proportional fluctuations in growth have been practically the same for all classes of trees. Only the rapid juvenile growth of young trees and the slow complacent growth of overmature or suppressed trees are likely to show erratic or negligible response.

By comparing the growth pattern, similarly determined, from different areas in southern and central Oregon and northeastern California, it was found that the same pattern of growth extended over a wide area. (See fig. 3.) Evidently there exists a broad climatic zone which influences and has dominated the growth pattern over a large region east of the Cascade Range.

At present the boundaries of this climatic zone are not clearly defined. Pinehurst, Oreg., at the summit of the southern Cascades, is the most westerly point examined which clearly shows the typical growth pattern. To the south the same pattern extends through the Modoc National Forest to Lookout and Alturas, Calif., and may extend on south to Susanville. All of the Fremont and Deschutes National Forests from Lakeview north to Bend, Oreg., show the same influence which extends on eastward to the Ochoco National Forest east of Prineville, Oreg. Detailed measurements have not been made from other portions of the region in the present study, but Meyer (10) has shown similar tendencies extending throughout the Blue Mountains and north throughout eastern Washington. It is evident that in its major phases we are dealing with climatic influences which are more or less general throughout the northern Great Basin region, and are only slightly modified by more local weather conditions.

In comparing the eastern Oregon pattern of ring growth with that of the big tree from the west slope of the Sierras, Huntington (7) and Antevs (1), very little similarity was found in the annual fluctuations or even in the decadal growth. The big tree record shows very uniform or complacent growth as compared with the marked fluctuations found in the ponderosa pine rings. This is undoubtedly due to the great differences in moisture conditions in the two localities. The big trees and the pines do, however, show a marked similarity in the long-swing fluctuations, and agree in this respect.

Agreement between the patterns of annual growth fluctuations of ponderosa pines in Arizona (Douglass (4))and those from eastern Oregon, for the period 1840 to 1918, was not evident from inspection, but did give a correlation ratio of $+0.41 \pm 0.09$ which may be considered as significant.

Normal tree growth.—Since there are large differences in the growth rates of individual trees according to age, diameter, tree class, position in the stand, and local influences, it is useless to compare yearly fluctuations in growth between different trees without first reducing these fluctuations to a common base. In other words, we must first determine a value for normal tree growth in order to have a base upon which fluctuations due to climate may be measured.

Reducing yearly growth to a percentage of the mean, as is shown in figure 2, is only accurate for relatively short periods of time, of less than 50 years, for it does not take into account the normal growth cycle of the tree, nor does it compensate for other factors which may influence growth rates over a long period of time.

A normal curve of radial growth for each area was determined by summating and taking the average growth according to age of all trees used in the study regardless of years during which such growth occurred. The rate of annual radial or diameter increment, for ponderosa pines used in this study, gradually increases up to about 75 years of age. By that time trees have reached an average diameter of 8 inches (100 mm radius) on poor sites and about 12 inches on good sites. From that point on, the rate of diameter growth gradually decreases until the trees are about 300 years of age. The growth curve then flattens out and diameter growth after 300 years becomes practically constant. (See fig. 4.)

Individual tree variation.—On comparing the growth curve of any individual tree against the general average or normal curve of growth, it was evident that this correction alone failed to compensate for large differences in growth rates due to differences in individual tree vigor, dominance, crowding, or sudden release due to fire or windthrow of neighboring trees. Therefore, individual tree variation was compensated for by plotting the decadal growth and then fitting a smooth trend line. This process was the same as making the assumption that the trend of average growth which a tree maintained during a period of 100 years or more was normal for that tree, and that deviations from this trend line were due to outside influences, including climate.

The smoothed growth-trend curves fitted to each tree's pattern tended to obscure any long-swing climatic changes of more than a century in length. To determine whether any such long-swing changes existed, the smoothed growth curve for each tree, which had been assumed to the normal for that tree, was then compared with the general average curve of growth according to age, and the deviations for each decade noted. Separate comparisons were made for trees between the ages of 75 and 150 years, between 150

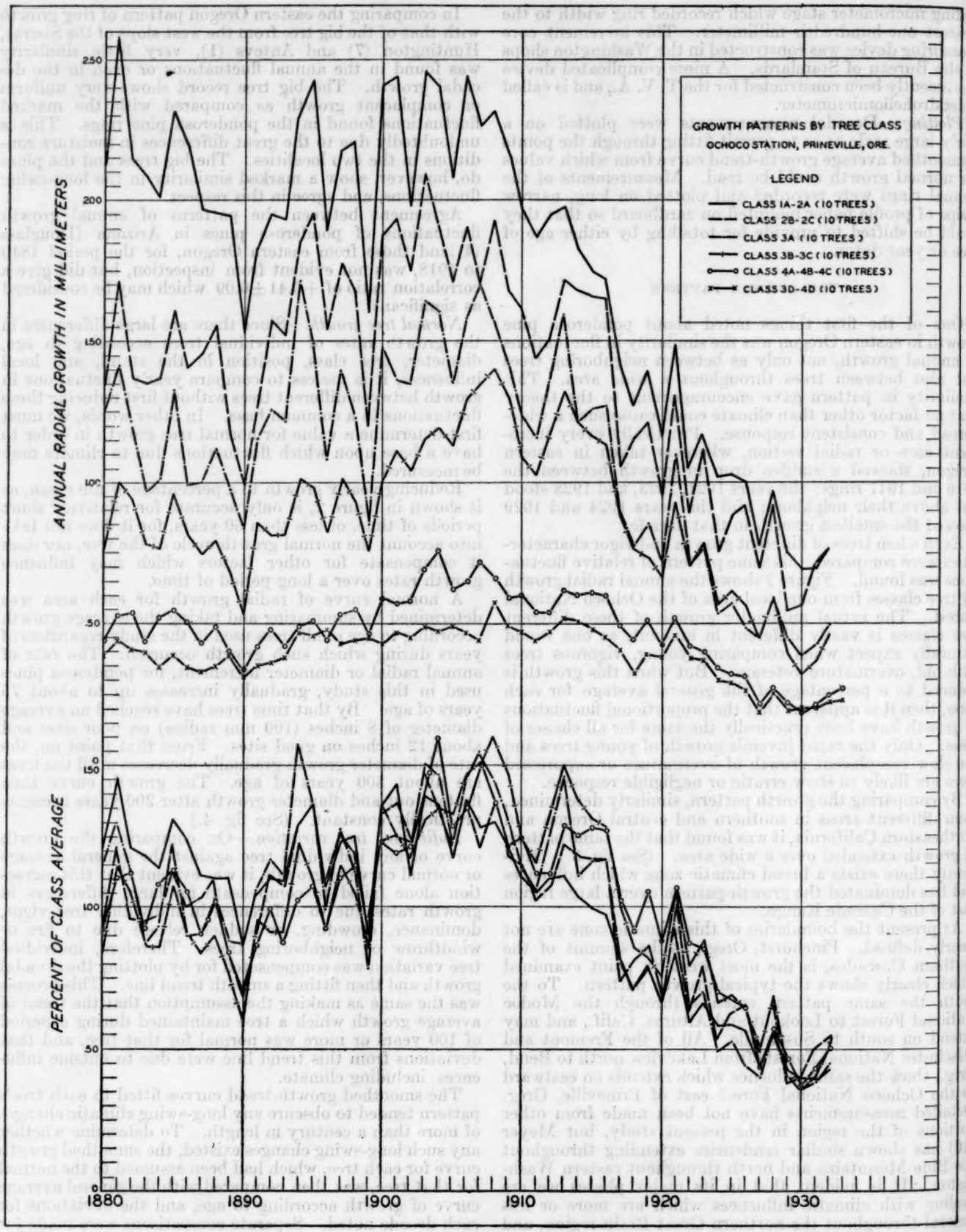

GROWTH PATTERNS BY TREE CLASS
OCHOCO STATION, PRINEVILLE, ORE.
LEGEND
CLASS 1A-2A (10 TREES)
CLASS 2B-2C (10 TREES)
CLASS 3A (10 TREES)
CLASS 3B-3C (10 TREES)
CLASS 4A-4B-4C (10 TREES)
CLASS 3D-4D (10 TREES)
ANNUAL RADIAL GROWTH IN MILLIMETERS
PERCENT OF CLASS AVERAGE
250
200
150
100
50
0
150
100
50
1880
1890
1900
1910
1920
1930

FIGURE 2.

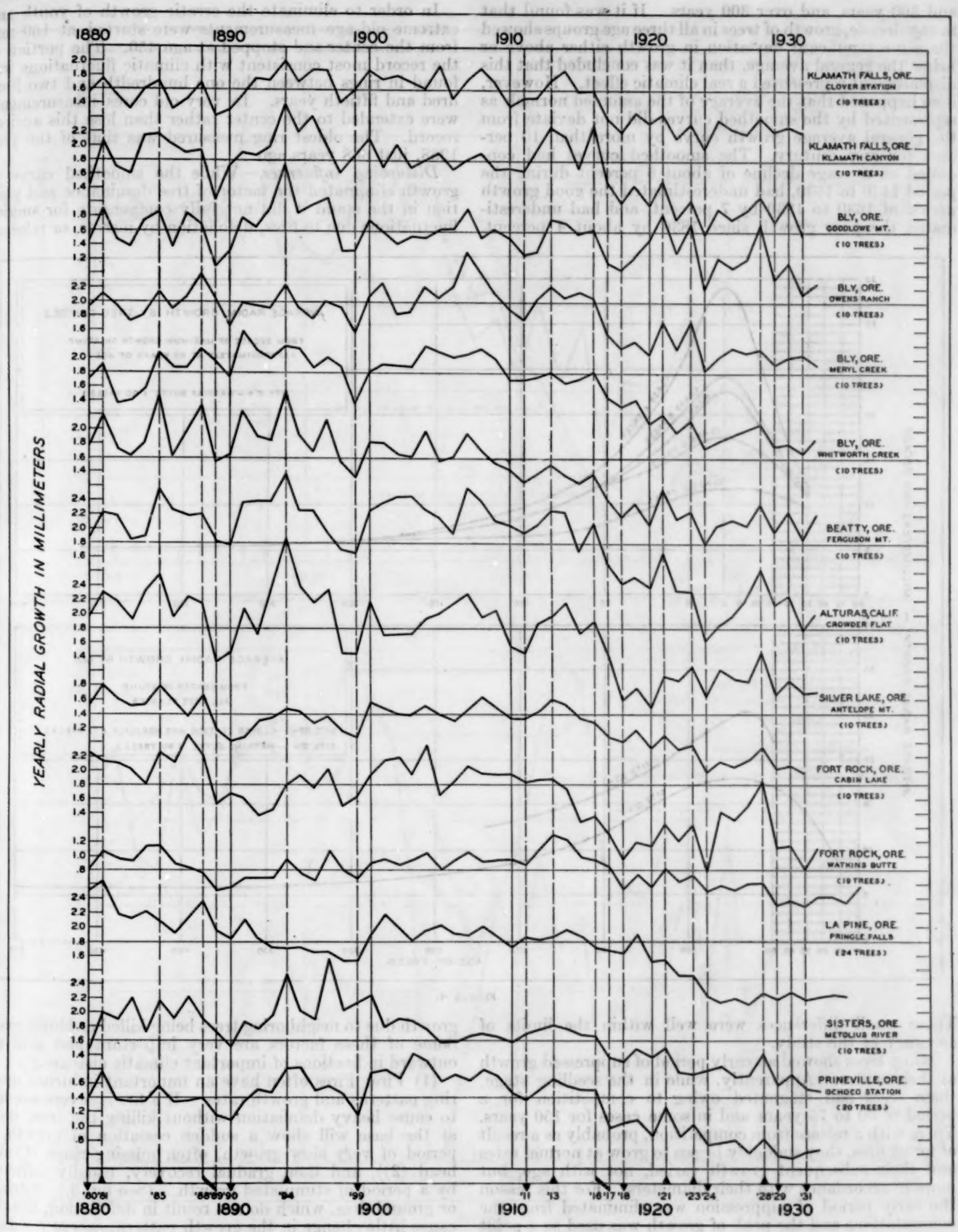

1880
1890
1900
1910
1920
1930
YEARLY RADIAL GROWTH IN MILLIMETERS
KLAMATH FALLS, ORE.
CLOVER STATION
(10 TREES)
KLAMATH FALLS, ORE.
KLAMATH CANYON
(10 TREES)
BLY, ORE.
GOODLOWE MT.
(10 TREES)
BLY, ORE.
OWENS RANCH
(10 TREES)
BLY, ORE.
MERYL CREEK
(10 TREES)
BLY, ORE.
WHITWORTH CREEK
(10 TREES)
BEATTY, ORE.
FERGUSON MT.
(10 TREES)
ALTURAS, CALIF.
CROWDER FLAT
(10 TREES)
SILVER LAKE, ORE.
ANTELOPE MT.
(10 TREES)
FORT ROCK, ORE.
CABIN LAKE
(10 TREES)
FORT ROCK, ORE.
WATKINS BUTTE
(10 TREES)
LA PINE, ORE.
PRINGLE FALLS
(24 TREES)
SISTERS, ORE.
METOLIUS RIVER
(10 TREES)
PRINEVILLE, ORE.
SCHOCO STATION
(20 TREES)
'80'81
'85
'88'89'90
'94
'99
'11
'13
'16'17'18
'21
'23'24
'28'29
'31

FIGURE 3.

and 300 years, and over 300 years. If it was found that in any decade, growth of trees in all three age groups showed the same significant deviation in growth either above or below the general average, than it was concluded that this displacement represented a real climatic effect. However, it so happened that the average of the assumed normals as represented by the smoothed curves did not deviate from the general average growth curve by more than 10 percent for any century. The smoothed curves had concealed an average decline of about 6 percent during the period 1430 to 1630, had underestimated the good growth period of 1630 to 1830 by 7 percent, and had underestimated the poor growth since 1830 by about 4 percent.

In order to eliminate the erratic growth of youth and extreme old-age measurements were started at 100 mm from the center and stopped at age 450. The portion of the record most consistent with climatic fluctuations was found in rings between the one hundredth and two hundred and fiftieth years. In very old cores measurements were extended to the center rather than lose this ancient record. The oldest ring measured was that of the year 1268, just 668 years ago.

Disturbing influences.—While the smoothed curve of growth eliminated the factor of tree dominance and position in the stand it did not fully compensate for sudden fluctuations due to fires, defoliation by insects, or released

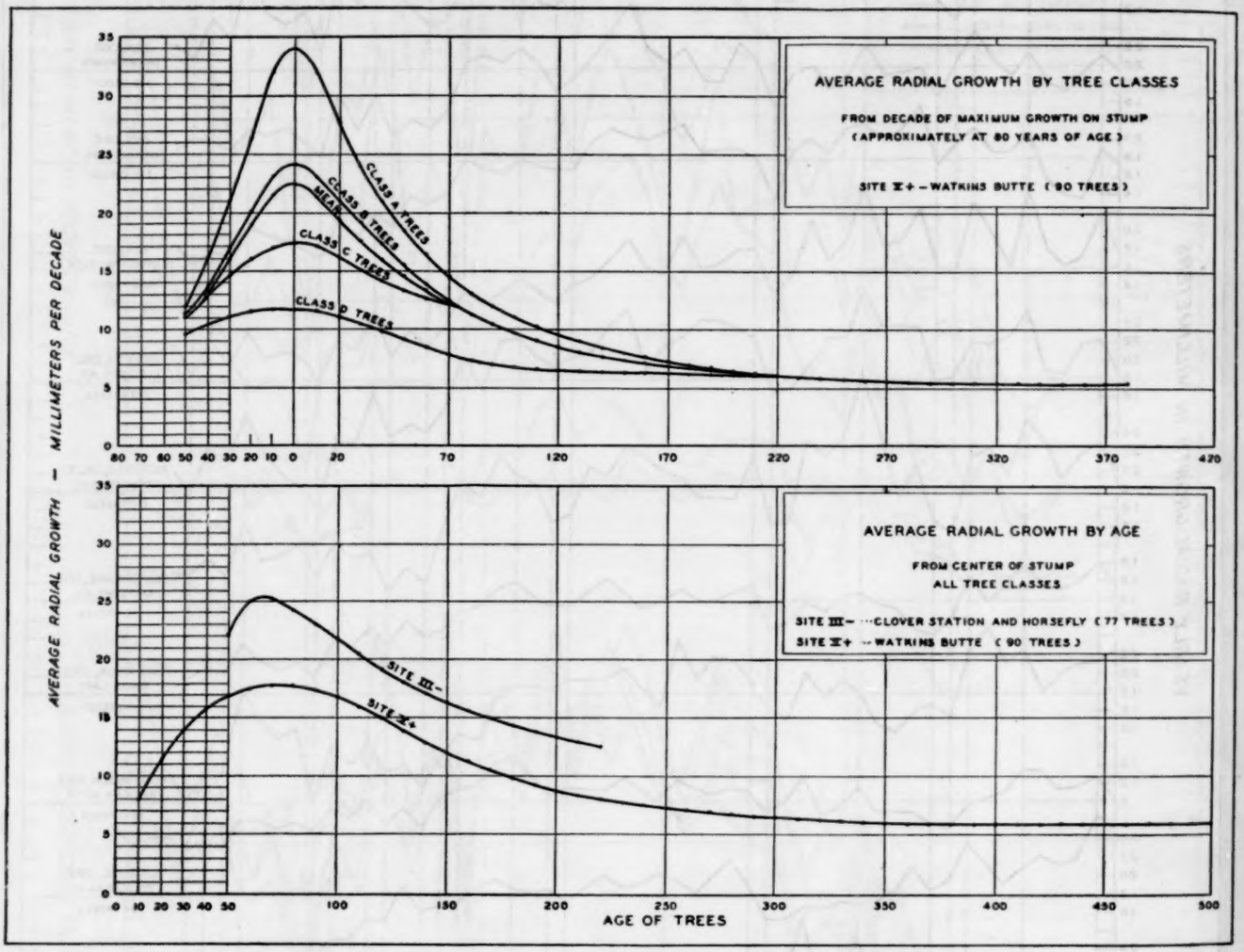


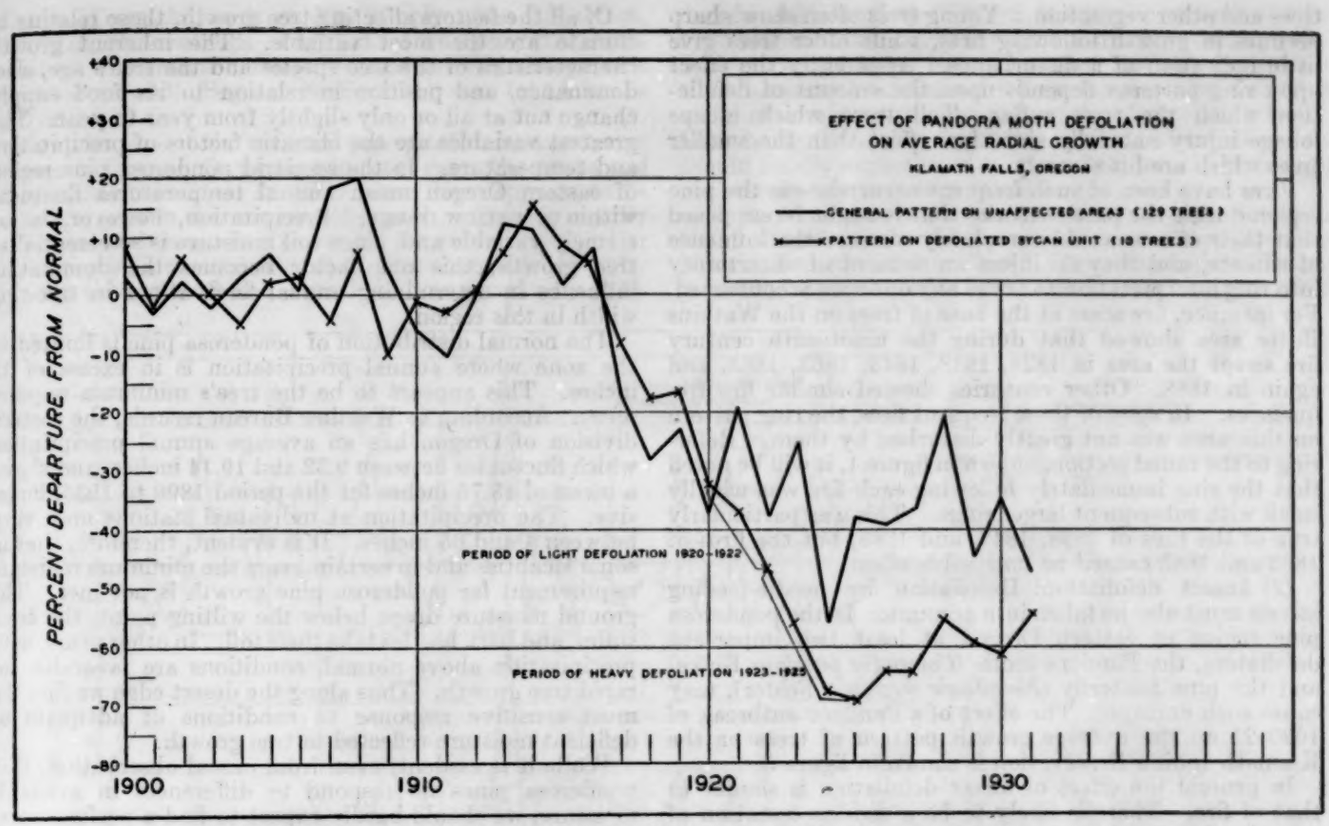
FIGURE 4.

These small differences were well within the limits of accuracy of the study.

Many trees showed an early period of suppressed growth at their center. Apparently, while in the seedling stage, these trees had stagnated owing to competition for a period of 50 to 75 years and in some cases for 150 years. Then, with a release from competition, probably as a result of forest fires, they suddenly began to grow at normal rates and their subsequent growth varied, not with age, but more in accordance with their diameters. For this reason the early period of suppression was eliminated from the computations and the peak of growth was used as a point of origin. (See fig. 4.)

growth due to neighboring trees being killed or blown over. Some of these factors are very important and give all outward indications of important climatic changes.

(1) Fire: Fires often have an important influence upon ring patterns and growth rates. If a fire is severe enough to cause heavy defoliation without killing the tree, rings at the base will show a sudden cessation of growth, a period of very slow growth, often missing rings (Craighead (2)), and then gradual recovery, usually followed by a period of stimulated growth. (See fig. 5.) Surface or ground fires, which do not result in defoliation, usually cause little change in the growth pattern, except a subsequent increase in growth due to elimination of competing


EFFECT OF PANDORA MOTH DEFOLIATION
ON AVERAGE RADIAL GROWTH
KLAMATH FALLS, OREGON
GENERAL PATTERN ON UNAFFECTED AREAS (129 TREES)
PATTERN ON DEFOLIATED SYCAN UNIT (10 TREES)
PERCENT DEPARTURE FROM NORMAL
+40
+30
+20
+10
0
-10
-20
-30
-40
-50
-60
-70
-80
PERIOD OF LIGHT DEFOLIATION 1920-1922
PERIOD OF HEAVY DEFOLIATION 1923-1925
1900
1910
1920
1930

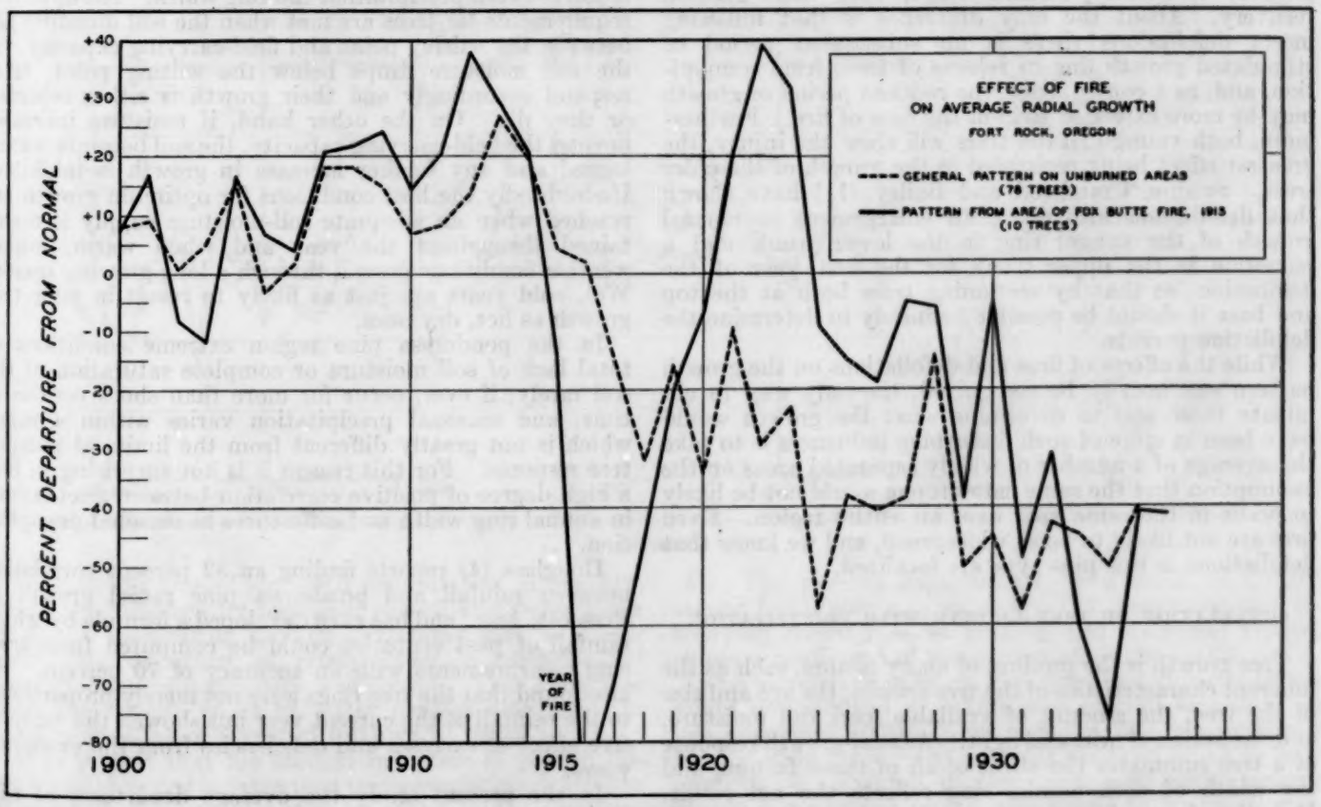

EFFECT OF FIRE
ON AVERAGE RADIAL GROWTH
FORT ROCK, OREGON
GENERAL PATTERN ON UNBURNED AREAS (78 TREES)
PATTERN FROM AREA OF FOX BUTTE FIRE, 1915 (10 TREES)
PERCENT DEPARTURE FROM NORMAL
+40
+30
+20
+10
0
-10
-20
-30
-40
-50
-60
-70
-80
YEAR OF FIRE
1900
1910
1915
1920
1930

FIGURE 5.

trees and other vegetation. Young trees often show sharp declines in growth following fires, while older trees give little indication of a disturbance. Apparently the effect upon ring patterns depends upon the amount of defoliation which the trees suffer. Tall trees which escape foliage injury naturally show less effect than the smaller trees which are hit severely.

Fires have been of such frequent occurrence in the pine region during the past centuries that it might be supposed that their effects would completely obscure the influence of climate, and they do inject an element of uncertainty into ring interpretation as far as any one area is concerned. For instance, fire scars at the base of trees on the Watkins Butte area showed that during the nineteenth century fire swept the area in 1824, 1838, 1843, 1863, 1883, and again in 1888. Other centuries showed similar fire frequencies. In spite of these frequent fires, the ring pattern on this area was not greatly disturbed by them. Referring to the radial sections shown in figure 1, it will be noted that the ring immediately following each fire was usually small with subsequent larger rings. This was particularly true of the fires of 1838, 1843, and 1888, but the fires of 1863 and 1883 caused no noticeable effect.

(2) Insect defoliation: Defoliation by needle-feeding insects must also be taken into account. In the ponderosa pine region of eastern Oregon at least two important defoliators, the Pandora moth (*Coloradia pandora* Blake) and the pine butterfly (*Neophasis menapia* Felder), may cause such damage. The effect of a Pandora outbreak of 1920–25 on the average growth pattern of trees on the Klamath Indian Reservation is shown in figure 5.

In general the effect of insect defoliation is similar to that of fire. There is likely to be a sudden cessation of growth, frequently missing rings, and then gradual recovery. About the only difference is that following insect defoliations there is no subsequent period of stimulated growth due to release of trees from competition, and, as a consequence, the reduced period of growth may be more extended than in the case of fire. Furthermore, both young and old trees will show the injury, the greatest effect being registered in the growth of the older trees. Swaine, Craighead and Bailey (**11**) have shown that defoliations also cause an enlargement or normal growth of the annual ring in the lower trunk and a reduction in the upper trunk for the first year of the defoliation, so that by sectioning trees both at the top and base it should be possible definitely to determine the defoliation periods.

While the effects of fires and defoliations on the growth pattern can usually be recognized, the only way to eliminate these and to determine what the growth would have been in spite of such disturbing influences is to take the average of a number of widely separated areas on the assumption that the same catastrophe would not be likely to occur in the same year over an entire region. Even fires are not likely to be so widespread, and we know that defoliations in this pine type are localized.

CORRELATION OF TREE GROWTH WITH PRECIPITATION

Tree growth is the product of many factors, such as the inherent characteristics of the tree species, the age and size of the tree, the amount of available food and moisture, and the action of heat and light. Annual-growth response of a tree summates the effect of all of these factors, and the width of each annual ring reflects the net result. It is, therefore, a better measure of good and poor growth periods than can be obtained by any number of direct measurements of each independent factor.

Of all the factors affecting tree growth, those relating to climate are the most variable. The inherent growth characteristics of the tree species and the tree's age, size, dominance, and position in relation to its food supply change not at all or only slightly from year to year. The greatest variables are the climatic factors of precipitation and temperature. In the semiarid ponderosa pine region of eastern Oregon mean annual temperatures fluctuate within a narrow range. Precipitation, however, is extremely variable and, since soil moisture is so essential to tree growth, this one factor becomes the dominating influence in determining annual fluctuations in tree-ring width in this region.

The normal distribution of ponderosa pine is limited to the zone where annual precipitation is in excess of 12 inches. This appears to be the tree's minimum requirement. According to Weather Bureau records, the eastern division of Oregon has an average annual precipitation which fluctuates between 9.32 and 19.14 inches, and shows a mean of 13.75 inches for the period 1890 to 1935, inclusive. The precipitation at individual stations may vary between 4 and 65 inches. It is evident, therefore, that in some localities and in certain years the minimum moisture requirement for ponderosa pine growth is not met. The ground moisture drops below the wilting point, the trees suffer, and bark beetles take their toll. In other years, with precipitation above normal, conditions are favorable for rapid tree growth. Thus along the desert edge we find the most sensitive response to conditions of adequate or deficient moisture reflected in tree growth.

While it is evident, even from casual observation, that ponderosa pines do respond to differences in available moisture, we should hardly expect to find a perfect correlation between precipitation and ring width. The optimum requirements for trees are met when the soil moisture lies between the wilting point and field-carrying capacity. If the soil moisture drops below the wilting point, trees respond accordingly and their growth is either retarded or they die. On the other hand, if moisture increases beyond the field-carrying capacity, the soil becomes waterlogged and any further increase in growth is inhibited. Undoubtedly the best conditions for optimum growth are reached when an adequate soil-moisture supply is maintained throughout the year and when warm, humid weather conditions prevail through a long growing season. Wet, cold years are just as likely to result in poor tree growth as hot, dry ones.

In the ponderosa pine region extreme conditions of total lack of soil moisture or complete saturation of the soil rarely, if ever, occur for more than short periods of time, and seasonal precipitation varies within a range which is not greatly different from the limits of possible tree response. For this reason it is not surprising to find a high degree of positive correlation between fluctuations in annual ring width and differences in seasonal precipitation.

Douglass (**4**) reports finding an 82 percent correlation between rainfall and ponderosa pine radial growth at Prescott, Ariz., and has even developed a formula by which rainfall of past centuries could be computed from tree-ring measurements with an accuracy of 70 percent. He also found that the tree rings were not merely proportional to the rainfall of the current year but showed the cumulative effect of excesses and deficiencies from the preceding years.

In the present study the average departures of ring growth from normal have been compared with the yearly departures of precipitation in eastern Oregon. This relationship is shown graphically in figure 6. A certain

degree of correlation is evident simply upon inspection. Applying the methods of statistical analysis, the coefficient of correlation between current growth and current seasonal rainfall (Sept. 1 to Sept. 1) was found to be $+0.50\pm0.09$.

Examination of the seasonal precipitation and tree-ring curves in figure 6 shows that in most cases the peaks and depressions coincide. In other cases there appears to be a lag of 1 year in the response of growth. This lag usually coincides with a similar 1-year lag in water run-off. For instance, the increased rainfall of 1926–27 was followed by the heaviest run-off and a peak of tree growth in 1928.

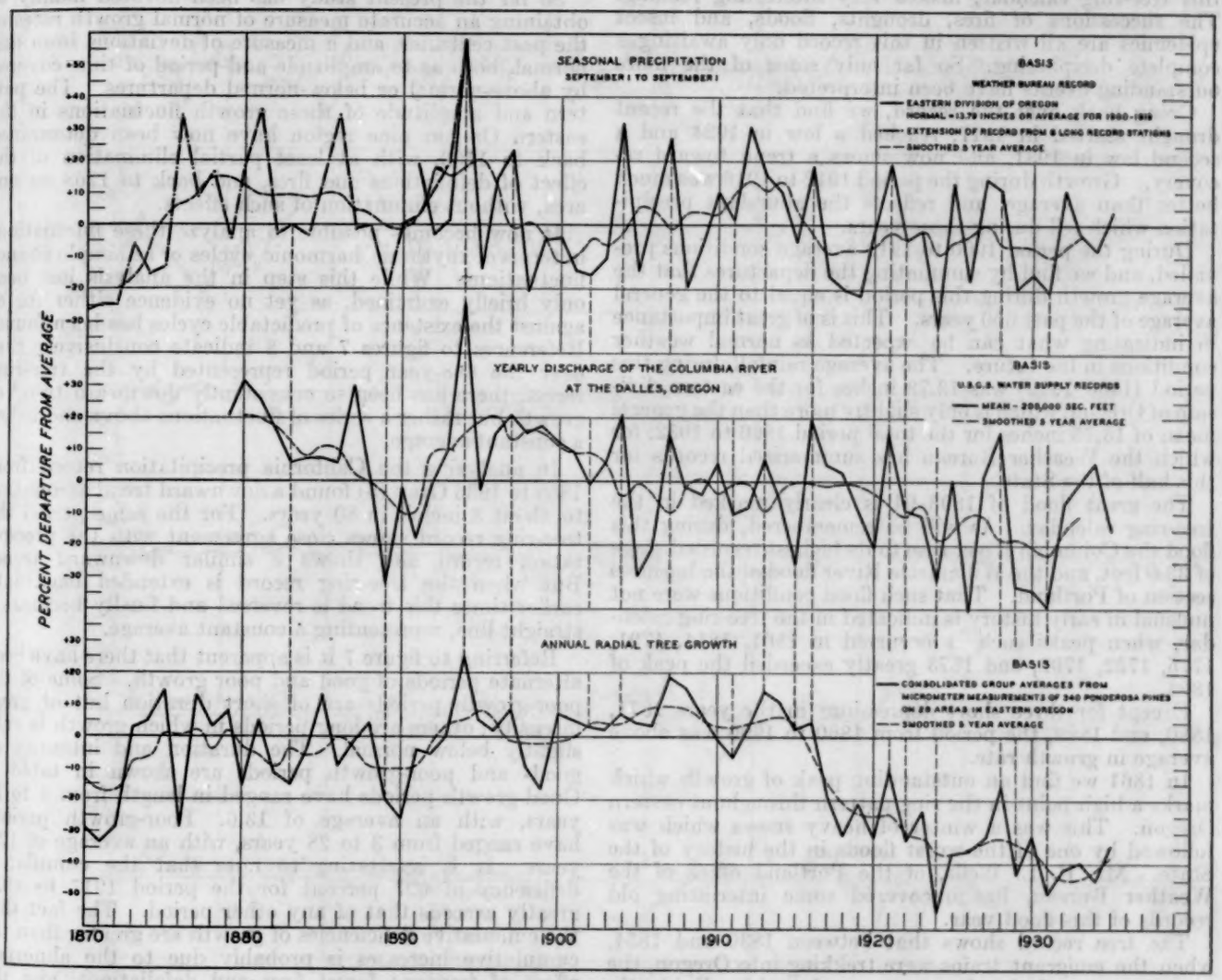


FIGURE 6.

The same was true of increased precipitation in 1911–12, which was followed by increased run-off and tree growth in 1913. Comparing growth deviations with a 2-year cumulative departure of precipitation, a coefficient of correlation of $+0.82\pm0.04$ was found. Thus, the tree rings show some effect of water conservation, and, in most cases, a lag of 1 year in full growth response.

It is evident that the marked reduction in growth following 1917 is due in large part to a cumulative deficiency of moisture, to a lowering of water tables, and to a physiological drought condition that is not strikingly evident in the yearly precipitation records. During the past two decades lake levels in eastern Oregon have receded. In 1926 Goose Lake and many others dried up completely. Springs which have been depended upon for watering stock for many years have dried up, streams have dwindled and dust-swept deserts have taken the place of once fertile farm lands. Judging from the rainfall record alone we should hardly expect such catastrophes, but the tree rings accentuate this long-swing deficiency.

This cumulative moisture deficiency is also shown in the record of the annual mean discharge of the Columbia River. Records of the United States Geological Survey give this information for The Dalles, Oreg., back to 1879 (6). The percent departures from a mean of 200,000 second feet is shown in figure 6. The correlation with the tree-ring record is most striking and statistical analysis shows a coefficient of correlation of $+0.56\pm0.09$.

The correlation between tree rings and climatic factors might be improved by taking into account several of the less important factors. For instance, the distribution of precipitation throughout the year has been found to be of importance. Rainfall in the spring and early summer during the growing period was found to be much more important than an excess of precipitation during the winter months. Variations in temperature and the length of the

growing season undoubtedly play a part. Multiple correlations including all of these minor factors have not as yet been determined.

THE TREE-RING CALENDAR

The combined pattern of growth from all areas in terms of percent departure from normal growth is shown in figure 7. In this chart the effects of fires and other agencies have been largely eliminated back to 1,500 by combining the averages.

The ancient history of eastern Oregon, as recorded in this tree-ring calendar, makes very interesting reading. The successions of fires, droughts, floods, and insect epidemics are all written in this record only awaiting a complete deciphering. So far only some of the more outstanding events have been interpreted.

Going back over the record, we find that the recent drought started in 1917, reached a low in 1924 and a second low in 1931, and now shows a trend toward recovery. Growth during the period 1912 to 1916 was much better than average, and reflects the abundant precipitation which fell during those years.

During the period 1900 to 1919 average conditions prevailed, and we find by summating the departures that the average growth during this period is equal to the general average of the past 650 years. This is of great importance in indicating what can be expected as normal weather conditions in the future. The average rainfall during this period (1900–1919) was 13.79 inches for the eastern division of Oregon, which is only slightly more than the general mean of 13.75 inches for the total period 1890 to 1932, for which the Weather Bureau has summarized records for this half of the State.

The great flood of 1893–94 is clearly marked in the tree-ring calendar. As will be remembered, during this flood the Columbia River rose to its highest recorded stage of 33.0 feet, and the Willamette River flooded the business section of Portland. That such flood conditions were not unusual in early history is indicated in the tree-ring calendar, when peaks such as occurred in 1861, 1814, 1791, 1775, 1752, 1702, and 1673 greatly exceeded the peak of 1894.

Except for three short depressions in the years 1871, 1880, and 1889, the period from 1860 to 1900 was above average in growth rate.

In 1861 we find an outstanding peak of growth which marks a high point in the ring pattern throughout eastern Oregon. This was a winter of heavy snows which was followed by one of the worst floods in the history of the State. Mr. E. L. Wells, of the Portland office of the Weather Bureau, has uncovered some interesting old records of this flood year.

The tree record shows that between 1839 and 1854, when the emigrant trains were trekking into Oregon, the country was suffering from a severe drought. Evidently Goose Lake, Harney Lake, and many other lakes in the region were dry at that time, for when Goose Lake dried up in 1925 for the first time in the memory of present settlers the ruts of a wagon road were clearly seen crossing the bed of the lake, indicating that in the 1840's there was no water in this lake to impede the progress of the early settlers. The tree-ring record indicates that this was undoubtedly the case, for the depression of growth rate during the 1840's and early 1850's was almost as severe as the present one.

From the year of discovery of Oregon in 1805, through the Lewis and Clark Expedition, during the period of early settlement and until the coming of the emigrants in 1840, the country was relatively wet according to the tree-ring record.

Carrying the record back for the previous five centuries, we can only speculate upon conditions through analogy. It seems fairly certain that the decade 1670 to 1680 was the wettest within the life span of the present living pine forests. The Seventeenth century was above normal in growth, the Sixteenth century as dry as the recent one, and the Fifteenth century was wet.

GROWTH CYCLES

So far the present study has been devoted mainly to obtaining an accurate measure of normal growth rates of the past centuries, and a measure of deviations from this normal, both as to amplitude and period of time covered by above-normal or below-normal departures. The pattern and amplitude of these growth fluctuations in the eastern Oregon pine region have now been determined back to 1500, with at least partial elimination of the effect of defoliations and fires, and back to 1268 on one area, without elimination of such effects.

It now becomes possible to analyze these fluctuations in terms of rhythmic harmonic cycles or as simple chance fluctuations. While this step in the analysis has been only briefly examined, as yet no evidence either for or against the existence of predictable cycles has been found. References to figures 7 and 8 indicate conclusively that over the 668-year period represented by the tree-ring record there has been so consistently downward trend of growth but rather a series of fluctuations above and below a constant average.

In analyzing the California precipitation record from 1850 to 1933 Gray (5) found a downward trend amounting to about 8 inches in 80 years. For the same period the tree-ring record shows close agreement with the precipitation record and shows a similar downward trend. But when the tree-ring record is extended back into earlier times this trend is reversed and finally becomes a straight line, representing a constant average.

Referring to figure 7 it is apparent that there have been alternate periods of good and poor growth. Some of the poor-growth periods are of short duration but of great intensity; others are long periods in which growth is only slightly below normal. The duration and intensity of good- and poor-growth periods are shown in table 1. Good-growth periods have ranged in length from 4 to 50 years, with an average of 13.6. Poor-growth periods have ranged from 3 to 28 years, with an average of 12.9 years. It is interesting to note that the cumulative deficiency of 627 percent for the period 1917 to 1936 greatly exceeds that of any other period. The fact that the cumulative deficiencies of growth are greater than the cumulative increases is probably due to the abnormal effect of frequent forest fires and defoliations, and the inherent potentialities of tree growth, for there is a much smaller range in the possible increase of tree growth above normal than in its possible decrease.

Combining duration and intensity, it is possible roughly to divide the more outstanding good- and poor-growth periods into three magnitudes, or degrees of importance. All important peaks of good growth are listed in table 2 and outstanding depressions in table 3. Taking into account the intervals between all the peaks tabulated, we find an average interval of 9.4 years between years of good growth and 7.8 years between years of poor growth. The range is from 2 to 33 years. Taking the intervals between peaks of second-degree magnitude, and between

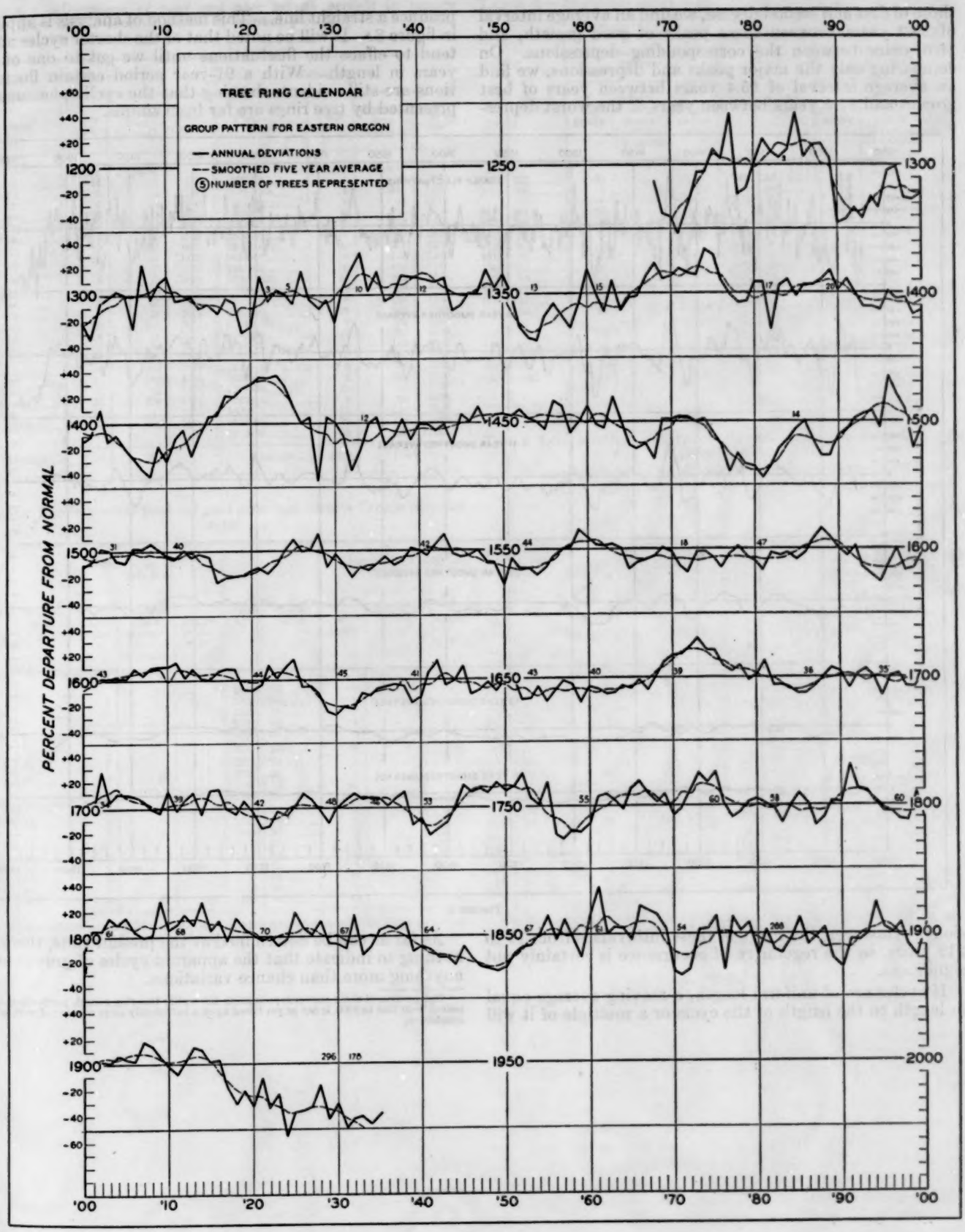

TREE RING CALENDAR
GROUP PATTERN FOR EASTERN OREGON
— ANNUAL DEVIATIONS
– – SMOOTHED FIVE YEAR AVERAGE
(5) NUMBER OF TREES REPRESENTED
PERCENT DEPARTURE FROM NORMAL
'00 '10 '20 '30 '40 '50 '60 '70 '80 '90 '00
1200 1250 1300
1300 1350 1400
1400 1450 1500
1500 1550 1600
1600 1650 1700
1700 1750 1800
1800 1850 1900
1900 1950 2000

FIGURE 7.

those of first and second degree, we find an average interval of 29.2 years between these peaks of good growth, and 15.0 years between the corresponding depressions. On comparing only the major peaks and depressions, we find an average interval of 55.4 years between years of best growth and 82.5 years between years of the worst depressions. However, the range of these intervals is from 19 to 219 years, so the regularity of occurrence is certainly not significant.

If cycles are of uniform length, a moving average equal in length to the length of the cycle or a multiple of it will produce a straight line. This method of analysis is applied in figure 8.[4] It will be noted that of the shorter cycles none tend to efface the fluctuations until we get to one of 45 years in length. With a 91-year period certain fluctuations are still evident, showing that the cyclic phenomena presented by tree rings are far from simple.

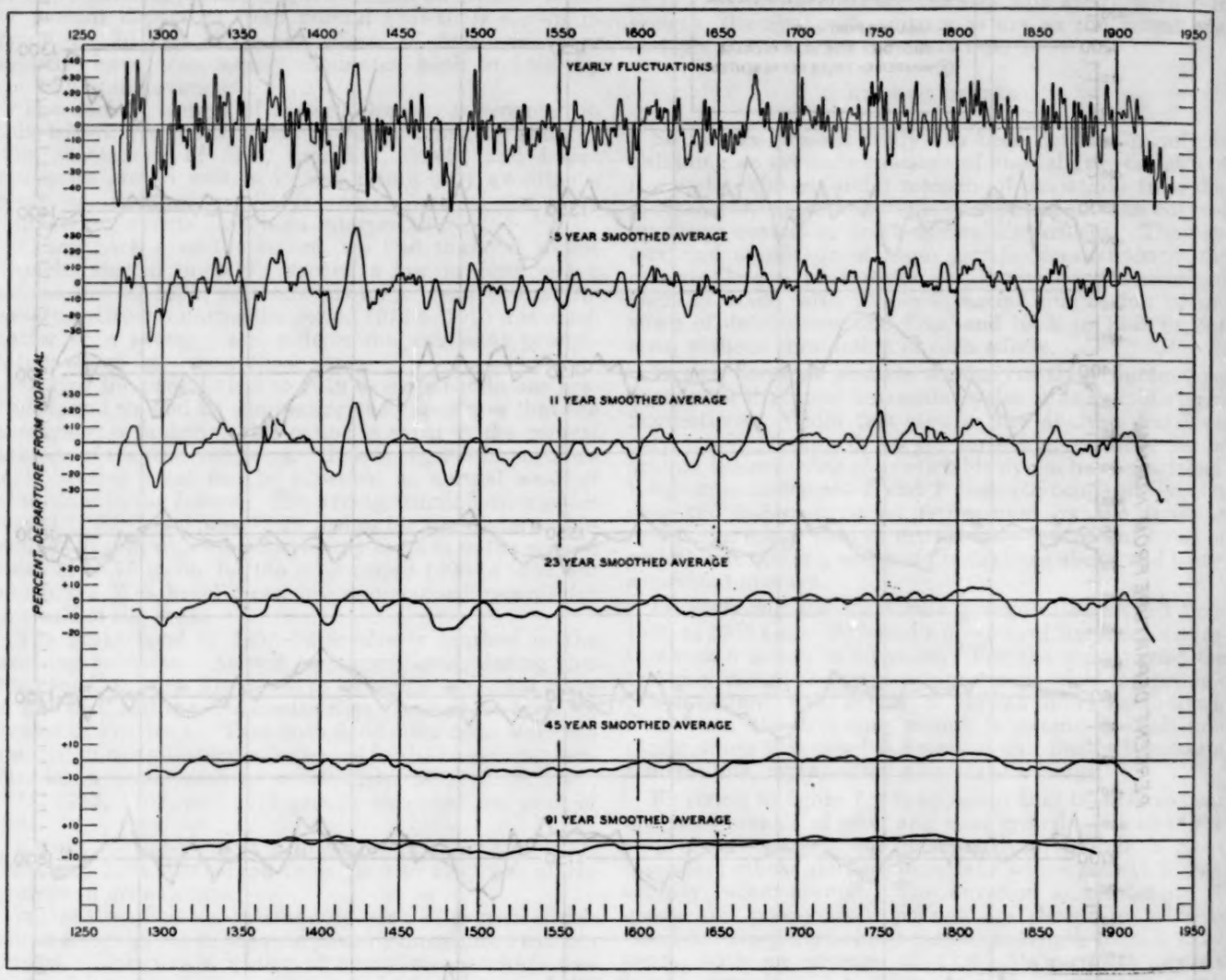


FIGURE 8.

As far as can be determined at the present time, there is nothing to indicate that the apparent cycles of growth are anything more than chance variations.

[4] The portion of these curves representing the earlier tree-ring record, particularly the period from 1268 to 1500, is not as yet based upon a sufficiently large number of trees to be conclusive.

TABLE 1.—*Durations of good and poor growth periods in eastern Oregon climatic zone as shown by annual growth of rings of Ponderosa pine*

Above normal				Below normal			
Dates	Duration	Cumulative increase	Best year	Dates	Duration	Cumulative deficiency	Worst year
	Years	*Percent*			*Years*	*Percent*	
1275–89	14	137	*1285*	1208–74	6	184	*1271*
1305–10	5	18	1307	1290–1304	14	343	*1290*
1321–26	5	13	1326	1311–20	9	93	1319
1331–51	20	161	*1333*	1327–30	3	36	1330
1367–77	10	155	*1374*	1352–66	14	210	*1365*
1386–92	6	45	1389	1378–85	7	11	1382
1415–27	12	*267*	1423	1393–1414	21	298	*1408*
1445–63	18	81	1463	1428–44	16	126	*1438*
1493–98	5	67	1496	1464–92	28	450	*1481*
1524–28	4	10	1528	1499–1523	24	210	*1516*
1540–47	7	3	1543	1529–39	10	109	1532
1557–64	7	37	1559	1548–56	8	119	1550
1587–92	5	95	1588	1565–86	21	148	1572
1602–25	23	128	*1611*	1593–1601	8	93	1595
1641–45	4	18	1642	1646–68	22	198	1650
1669–81	12	*180*	*1673*	1626–40	14	199	*1630*
1688–1738	50	111	*1702*	1682–87	5	47	1686
1745–55	10	*180*	*1752*	1739–44	5	76	1741
1761–76	15	145	1775	1756–60	4	102	1757
1789–94	5	62	1791	1777–88	11	35	1787
1800–1838	38	*212*	*1814*	1795–99	4	22	1798
1854–69	15	111	1861	1839–53	14	254	*1849*
1884–1916	22	109	1894	1870–93	23	138	1890
				1917–36	19	627	*1931*
Average	13.6	101		Average	12.9	172	

TABLE 2.—*Important peaks of good growth in eastern Oregon climatic zone*

Date	Magnitude	Interval (in years) between: All peaks	Intermediate peaks [1] (and major peaks)	Major peaks only
1913	3d			
1907	3d	6		
1894	1st	13		
1885	3d	9		
1877	3d	8		
1875	3d	2		
1868	3d	7		
1866	2d	2	28	
1861	1st	5	5	33
1857	3d	4		
1855	3d	2		
1838	3d	17		
1832	3d	6		
1828	3d	4		
1825	3d	3		
1818	3d	7		
1814	1st	4	47	47
1809	2d	5	5	
1805	3d	4		
1803	3d	2		
1799	3d	4		
1791	2d	8	18	
1775	1st	16	16	39
1773	2d	2	2	
1766	3d	7		
1755	3d	11		
1752	1st	3	21	23
1749	3d	3		
1747	2d	2	5	
1745	3d	2		
1738	3d	7		
1732	3d	6		
1726	3d	6		
1716	3d	10		
1713	3d	3		
1702	1st	11	45	50

[1] In this column peaks of 3d degree magnitude are ignored and only the longer intervals between peaks of either first or second degree magnitude are listed.

TABLE 2.—*Important peaks of good growth in eastern Oregon climatic zone*—Continued

Date	Magnitude	Interval (in years) between: All peaks	Intermediate peaks [1] (and major peaks)	Major peaks only
1681	3d	21		
1673	1st	8	29	29
1645	3d	28		
1642	3d	3		
1625	3d	17		
1622	3d	3		
1611	2d	11	62	
1588	3d	23		
1559	3d	29		
1543	3d	16		
1528	3d	15		
1496	1st	32	115	177
1463	3d	33		
1460	3d	3		
1456	3d	4		
1447	3d	9		
1423	1st	24	73	73
1402	3d	21		
1389	3d	13		
1374	1st	15	49	49
1371	3d	3		
1368	2d	3	6	
1350	3d	18		
1348	3d	2		
1341	2d	7	27	
1335	3d	6		
1333	1st	2	8	41
1326	3d	7		
1321	3d	5		
1307	2d	14	26	
1285	1st	22	22	48
1281	2d	4	4	
1277	2d	4		
	Average	9.4	29.2	55.4

TABLE 3.—*Important depressions of poor growth in eastern Oregon climatic zone*

Date	Magnitude	Interval (in years) between: All depressions	Intermediate depressions [1] (and major depressions)	Major depressions only
1931	1st			
1929	2d	2	2	
1924	2d	5	5	
1918	3d	6		
1899	3d	19		
1890	2d	9	34	
1883	3d	7		
1880	3d	3		
1876	2d	4	14	
1871	2d	5	5	
1859	3d	12		
1849	1st	10	22	82
1844	2d	5		
1839	3d	5		
1833	3d	6		
1831	3d	2		
1800	3d	31		
1798	2d	2	51	
1787	3d	11		
1783	3d	4		
1777	3d	6		
1757	2d	20	41	
1741	2d	16	16	
1730	3d	2		
1729	3d	10		
1721	3d	8		
1695	3d	26		
1686	2d	9	55	
1667	3d	19		
1659	2d	8	27	
1655	2d	4	4	
1652	3d	3		
1646	3d	6		
1639	3d	7		
1633	2d	6	22	
1630	1st	3	3	219

[1] In this column peaks of 3d degree magnitude are ignored and only the longer intervals between peaks of either first or second degree magnitude are listed.

TABLE 3.—*Important depressions of poor growth in eastern Oregon climatic zone*—Continued

Date	Magnitude	Interval (in years) between: All depressions	Intermediate depressions [1] (and major depressions)	Major depressions only
1598	3d	32		
1595	2d	3	35	
1581	3d	14		
1576	3d	5		
1572	2d	4	23	
1565	3d	7		
1554	3d	11		
1550	2d	4	22	
1537	3d	13		
1532	2d	5	18	
1529	3d	3		
1522	3d	7		
1519	3d	3		
1516	1st	3	16	114
1509	3d	7		
1505	3d	4		
1499	2d	6	17	
1489	2d	10	10	
1481	1st	8	8	35
1477	2d	4	4	
1468	2d	9	9	
1465	2d	3	3	
1444	3d	21		
1439	3d	5		
1436	3d	3		
1432	2d	4	33	
1428	2d	4	4	
1413	2d	15	15	
1410	2d	3	3	
1408	1st	2	2	73
1399	3d	9		
1395	3d	4		
1382	2d	13	26	
1362	2d	20	20	
1358	2d	4	4	
1353	1st	5	5	55
1344	3d	9		
1330	2d	14	23	
1328	3d	2		
1319	2d	9	11	
1316	3d	3		
1314	3d	2		
1306	2d	8	13	
1301	2d	5	5	
1299	2d	2	2	
1295	2d	4	4	
1293	2d	2	2	
1290	1st	3	3	63
1278	2d	12	12	
1271	1st	7	7	19
	Average.	7.8	15.0	82.5

[1] In this column depressions of 3rd degree magnitude are ignored and only the longer intervals between depressions of either first or second degree magnitude are listed.

SUMMARY

Through a study of tree rings in eastern Oregon it has been possible to arrive at an index of the ancient climatic history back to the year 1268. Micrometer measurements of annual radial growth of 1,240 ponderosa pines taken in 44 different localities of eastern Oregon have given a sound statistical basis for this study.

It was discovered that a broad climatic influence has uniformly dominated the growth pattern over a wide area of eastern Oregon and northern California. Any sample of ten selected trees was sufficient to show the same fluctuations of good and poor growth and outstandingly good and poor years, except for short periods where local influences such as fires, windfalls, or defoliations obscured the general pattern.

The boundaries of this climatic zone are not as yet well defined, but in its broader aspects it probably takes in all of the northern Great Basin region, from the Cascades to the Rocky Mountains, including the drainages of the Pitt, Klamath, Deschutes, Snake, and Columbia Rivers. Uniformity of tree-ring pattern has been found in this study from Alturas, Calif., north to the Metolius River, and from the summit of the Cascades eastward to the southern portion of the Blue Mountain Range. Meyer (**10**) has shown that the same general tendencies exist throughout the Blue Mountains and northward throughout eastern Washington. Since tree-ring patterns reflect such general agreement over broad regions, they are undoubtedly good indicators of such weather conditions as affect plant growth.

A significant correlation was found between seasonal precipitation and tree growth. On comparing the cumulative effect of 2 years of precipitation with tree-ring growth, a highly significant correlation ratio was found. By taking into account the distribution of rainfall through the year and the cumulative moisture through several seasons, an even higher degree of correlation may undoubtedly be found. The width of each annual ring represents a summation and net effect of all the factors influencing tree growth. Thus the tree rings become a better measure of good or poor periods for plant growth than can possibly be obtained through any number of weather-recording instruments.

The tree-ring record for eastern Oregon indicates that during the past 650 years there has been no general trend toward drier or wetter years. If such a trend exists, the change over a 650-year period is so slight that it is obscured by other fluctuations. Average growth for the 20-year period 1900 to 1919 was found to be identical with the average growth during the past 650 years. There have been important fluctuations in growth throughout the entire period, however, with alternate periods of good and poor growth.

All tree-ring measurements agree in showing that a very critical subnormal growth period has existed since 1917. This slowing down of the growth rate is undoubtedly the result of deficient precipitation and lowered water tables. As compared with other drought periods, the present one is the most severe and critical that the present forests have experienced in the last 650 years. Several other periods have exceeded the present one in duration of subnormal growth, but none has approached it for severity. Growth in 1931, the poorest year, was 68 percent below normal.

The tree-ring record indicates that the last period of 19 years of drought and poor tree growth represents a major fluctuation in a broad climatic cycle which eventually will be followed by a wet period of better than average growth. No rhythmic cycle has been found which would permit a prediction as to when this reversal in trend will occur.

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NOCTURNAL SURFACE-SOIL TEMPERATURES, AIR TEMPERATURES, AND GROUND INVERSIONS IN SOUTHERN ARIZONA

W. V. TURNAGE

[Desert Laboratory, Carnegie Institution of Washington, Tucson, Ariz., February 1937]

The frequency and magnitude of nocturnal temperature inversions in the Southwest, especially in the dry and warm Sonoran Desert, have been discussed by MacDougal,[1] Shreve,[2] and Douglass.[3] MacDougal and Shreve have pointed out the significance of "cold air drainage" for the distribution of plants in the region. Douglass has described an optical device which can be used to observe air currents at night, and had recorded some of his observations of these currents.

Thermograph traces from the Desert Laboratory, Tucson, Ariz., indicate that during 1936 two-thirds of the nights there had a pronounced ground inversion. Tucson is located in the Santa Cruz River basin at an elevation of 2,300 feet. Ten miles west the Tucson Mountains rise to an elevation slightly over 4,000 feet; 15 miles north are the Catalina Mountains (9,000 feet); 20 miles east are the Rincon Mountains (8,000 feet); and 40 miles south are the Santa Rita Mountains (9,000 feet). Below 6,000 feet the vegetation is a subtropical desert type while that of the higher elevations is coniferous forest. The Desert Laboratory is located on the north slope of Tumamoc Hill, 1 mile west of Tucson and of the usually dry bed of the Santa Cruz River, and is 330 feet above the flood plain. Tumamoc Hill rises 750 feet above the plain.

A thermograph at the laboratory and another on the flood plain near the base of the Hill, both in shelters 5 feet above the ground, are in continuous operation. The difference between the minimum readings of the two has been used as a crude index of the magnitude of the inversion each night. Recent readings on the summit of Tumamoc Hill indicate that the inversion, on nights when well developed, may extend to the hill top. The normal difference between the flood plain and Laboratory stations on inversion nights of 1936 was 9° F. although differences of 15° F. were not unusual and one of 23° F. occurred. During the summer rainy season inversions are usually lacking or poorly developed. The dry months of April and May have the most pronounced inversions, as do the dry periods of winter. Over the town a smoke haze develops under these inversions, but over the scantily populated basins of the region I have observed little haze under the inversions. Dew deposition on the ground during an inversion is uncommon. High cirrus clouds and winds less than 6 miles per hour do not seem to alter materially the difference in minimum temperatures between the laboratory and flood plain stations.

Typical data selected from a large number of observations are presented in the accompanying table. The readings, unless noted otherwise, were obtained with a thermocouple (no. 24 advance—copper wires) and a portable type Leeds and Northrup galvanometer. As the coldest air was found immediately above the ground, the air temperature at the height of 1 inch is used throughout the table. Temperatures of the surface soil underlying the observed air layers are listed, care having been taken in the measurements to eliminate the influence of the observer's body. The observations were made on soil locally free of vegetation and with unobstructed vista of the sky. Readings with mercurial thermometers for the surface soil were made by inserting the bulbs as shallowly as possible into the soil; and for the air the bulbs were openly exposed. Experience has shown that the minimum temperature of the soil surface is obtained rather more accurately than that of the air. Each group of readings represents one night. On each night, except that of group I, there was a well-developed inversion.

[1] MacDougall, D. T.: Influence of Inversions of Temperature, Ascending and Descending Currents of Air, upon Distribution, Boston, 1900.
[2] Shreve, Forrest: Cold Air Drainage, *Plant World*, 1912; Winter Temperatures and Distribution of Plants, *Am. Jour. Botany*, 1914.
[3] Douglass, A. E.: Study of Atmospheric Currents by Aid of Large Telescopes, and the Effects of Such Currents on the Quality of the Seeing, American Meteorological Journal, March 1895; Atmosphere, Telescope, and Observer, *Popular Astronomy*, June, 1897; Effect of Mountains on Quality of the Atmosphere, *Popular Astronomy*, 1899.

Group	Station	Elevation	Date	Time	Sky	Soil	Air at 1 in.	Temperature of surface (°F.)		
								Soil	Snow	Rock
		Feet					°F.			
I	Santa Cruz Basin	2,330	Dec. 28, 1936	10 p. m.	Ci-St; overcast, turbulent.	Moist clay	52.8	51.3		
II	Santa Cruz Basin	2,330	Jan. 5, 1937	10 p. m.	Clear; calm	Moist clay	32.0	32.5		
	do	2,330	Jan. 6, 1937	6 a. m.	do	do	28.6	29.1		
	Tumamoc hill slope	2,660	Jan. 6, 1937	Minimum	do	do	[1] 31.2	[1] 30.2		
III	Santa Cruz Basin	2,330	Dec. 1, 1936	10 p. m.	do	do	36.9	37.4		
	do	2,330	Dec. 2, 1936	6 a. m.	do	do	27.4	29.8		
	do	2,330	Dec. 2, 1936	Minimum	do	do	[1] 24.6			
	Tumamoc hill slope	2,660	Dec. 2, 1936	do	do	do	[1] 24.6	[1] 28.4		
IV	Catalina Mountain canyon	7,650	Nov. 17, 1936	6 p. m.	Clear; light breeze	Dry sand	37.4	37.7		
	do	7,650	Nov. 17, 1936	12 p. m.	do	do	30.6	32.0		
	do	7,650	Nov. 18, 1936	6 a. m.	do	do	27.9	29.3		
	Tumamoc hill slope	2,660	Nov. 18, 1936	Minimum	Clear; calm	Dry clay	[1] 37.1	[1] 41.0		
	Santa Cruz Basin	2,330	Nov. 18, 1936	do	do	do	[1] 33.8			
V	Baboquivari Peak	7,860	Dec. 12, 1936	9 p. m.	Clear; windy	Wet sand; rock	34.1	30.9	26.4	
	do	7,860	Dec. 13, 1936	6 a. m.	do	do	32.7	30.5	26.4	34.5
	Baboquivari Basin	3,500	Dec. 13, 1936	Minimum	Clear	Dry sand	[1] 30.2			
VI	Tucson Mountain ridge	3,200	Jan. 28, 1937	10 p. m.	Thin Ci; calm	Dry sand	43.7	41.5		
	Tucson Mountain arroyo	2,500	Jan. 28, 1937	10:30 p. m.	do	do	37.4	37.9		
	Santa Cruz Basin	2,330	Jan. 28, 1937	9 p. m.	do	Dry clay	[1] 32.0			

[1] Denotes mercurial thermometer readings.

NOTE.—Baboquivari Peak is about 40 miles southwest of the Santa Cruz Basin.

Observations of this type—made intermittently during the night and at one or only a few stations—can be misleading. Fitful breezes may import warmer or colder air to the vicinity of the instrument shortly before an observation is taken. Stations may be poorly selected in spite of efforts to find representative or extreme conditions. The "cold air drainage" may actually have its source in none of the locations where measurements are taken. More stations and more nearly continuous observations are desirable. Nevertheless, certain tentative conclusions are suggested by the data.

Group I presents a condition not uncommon on cloudy and windy nights—the surface of the basin soil cooling to a lower temperature than the air overlying it. Group II shows relations on an inversion night—the coldest air in the basin having a temperature lower than that of the basin soil and of the hill-slope soil and air. The air on the hill slope is the thin layer of cold air near the soil which on this particular night was 10° F. colder than the air 5 feet above the ground. The difference in the basin between these two heights is much less, being on this night 4° F.

Readings in a mountain canyon are given in group IV. The drainage of cold air down the canyon was easily detected, this air being colder than the soil of the canyon. This air, however, was not cold enough to reach the basin gravitationally unless it underwent considerably more cooling during its descent. Observations on other nights at lower elevations (group VI) did not reveal any stream of air sufficiently cold to reach the basin gravitationally. If this stream of air at high elevations does cool sufficiently on its journey to descend to the basin, it must have overcome the adiabatic warming of approximately 5.5° F. per 1,000 feet of descent.

The greatest observed difference between nocturnal soil and air temperatures (with the former the colder) are given in group V, the station being a high, isolated peak. Snow on the peak was considerably colder than both air and soil; the soil was frozen to a depth of several inches. Bare rock nearby, however, was warmer than the air. On the same peak, when there was no snow present, as on the night of January 20, 1936, the air became ½° F. colder than the soil; but on the night of May 16, 1936, the soil became 3° F. colder than the air.

At midday in the shade of a cliff at 4,000 feet elevation, moist soil has been observed to be 12.5° F. colder than the air. Beneath the surface this soil was frozen, perhaps the result of low temperatures the previous week. However, snow and frozen soil on the mountains are rare during the season of greatest basin-inversions.

THE GEOMETRICAL THEORY OF HALOS—IV

By EDGAR W. WOOLARD

[Weather Bureau, Washington, D. C., April 1937]

PART 2. CALCULATION OF POSITIONS OF IMAGES ON THE CELESTIAL SPHERE

From the general Formulae I, II, or III (or the appropriate special case of some one of these) the position of any image, *relative to the source*, produced by prismatic refraction, simple reflection, or prismatic refraction in combination with an internal reflection, may always readily be computed. These formulae will now be applied to derive formulae for the position *relative to the horizon* when the source is the sun or the moon at a given altitude; the derivation is essentially a transformation from spherical coordinates relative to the principal plane, or the reflecting plane, to the familiar horizon coordinate system of astronomy (with azimuths measured from the vertical circle through the sun).

IMAGES PRODUCED BY PRISMATIC REFRACTION WITHOUT INTERNAL REFLECTION

The derivation of the desired formulae may be accomplished by superimposing figures 5, 7, 11 in the proper orientation on the celestial sphere.[1] Figure 5 is the one required in the case of prismatic refraction without internal reflection.

Images produced by a dihedral angle with vertical refracting edge (principal plane horizontal).—Place figure 5 on the celestial sphere as in figure 12, with P' at the zenith Z, the great circle PRP on the horizon EME, and S in the position of the sun or the moon at altitude H above the horizon.

Then evidently $h=H$; and to compute the altitude H', the azimuth ζ from the solar vertical, the deviation D, and the position angle A' (measured from above the luminary) of the image S', at any given value of H, we have immediately from Formulae I the equations that comprise Formulae A. (It is of course unnecessary to make any actual use of equation (1) in the calculation if table 3 is used.)

[1] These figures appear in Papers II, III. The figures in the present paper are numbered consecutively with those in the preceding two papers.

FORMULAE A

CALCULATION OF THE IMAGE PRODUCED BY A DIHEDRAL REFRACTING ANGLE WITH VERTICAL REFRACTING EDGE

Parameter: H, $0° \leq H \leq \arccos\left\{\sqrt{\mu^2-1}\tan\frac{\alpha}{2}\right\}$

Argument: i_1

Calculation of D, A', H', ζ:

(1) $\mu'=\sqrt{\dfrac{\mu^2-\sin^2 H}{1-\sin^2 H}}$ Table 2

(2) $\sin r_1=\dfrac{\sin i_1}{\mu'}$,

$$\arcsin\left\{\sin\alpha\sqrt{\mu'^2-1}-\cos\alpha\right\}\leq i_1\leq 90° \qquad \text{Table 3}$$

(3) $r_1'=\alpha-r_1$

(4) $\sin i_1'=\mu'\sin r_1'$ Table 3

(5) $D'=i_1+i_1'-\alpha$

(6)
$$\begin{cases} D=2\arcsin\left\{\sin\frac{1}{2}D'\cos H\right\}, & D<D' \\ D_o'=2\arcsin\left\{\mu'\sin\frac{\alpha}{2}\right\}-\alpha \\ D_m'=180°-\left\{\alpha+\arccos\left[\mu'\sin\left(\alpha-\arcsin\frac{1}{\mu'}\right)\right]\right\} \\ A'=\operatorname{arccot}\left\{\tan\frac{1}{2}D'\sin H\right\} \end{cases}$$

(7)
$$\begin{cases} H'=H \\ \zeta=D' \end{cases}$$

[See figure 12. These formulae are obtained by putting $h=H$ in Formulae I.]

Images produced by a dihedral angle with horizontal refracting edge (principal plane vertical.)—To compute the image produced, at any altitude of the sun or moon, when

the refracting edge of an angle is in any azimuth and the faces of the angle at any inclination to the horizontal, superpose figure 5 on the celestial sphere as shown in figure 13. The orientation of the face of incidence is most conveniently specified by the inclination of the normal, as measured by the angle t ($<180°$) between the horizontal and the normal, reckoned from the point on

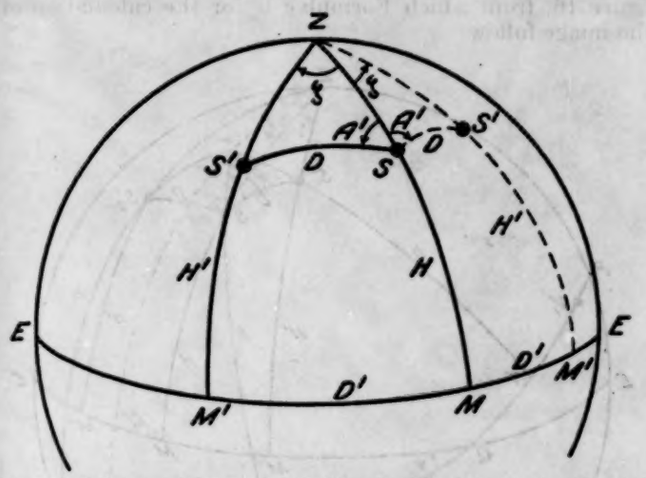


FIGURE 12. *Calculation of the image produced by a dihedral refracting angle with vertical refracting edge.* See Formulae *A*. *Z*, zenith; *EME*, horizon; *S*, luminary, at altitude *H*; *S'*, image; *D*, deviation; *A'*, position angle; *H'* altitude of image; ζ, azimuth of image. (*Cf.* fig. 5.)

the horizon below R, and taken positive or negative according as the normal is directed above or below the horizon.

The numerical value of i_1 is always the arc between N and R (see figures 4 and 5), and hence is the difference between t and δ, the altitude of R; but this difference must be taken with the proper algebraic sign: The range of

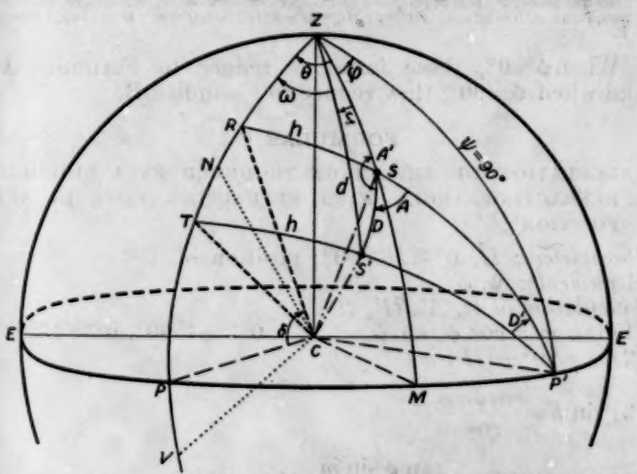


FIGURE 13. *The image produced by a dihedral refracting angle with horizontal refracting edge.* (*Cf.* figs. 4 and 5.) *Z*, zenith; *EME*, horizon; *S*, luminary; *NPV*, principal plane; *P*, pole of principal plane; *V*, vertex of refracting angle; *N*, normal at point of incidence; *C*, observer; *SC*, incident ray; *RC*, projection of incident ray on principal plane; *h*, inclination of incident ray to principal plane; *S'*, image; $NCR=i_1$; $NCP=t$; $NCV=90°$. *D'* is always toward V.

transmission extends at most (see fig. 2) from a point between V and N to the point 90° beyond N. Take (fig. 14) a refracting angle with the vertex V and the normal N in the positions V_1, N_1, respectively, so that $i_1=90°$; and let the angle rotate clockwise. Until N reaches E, $t<0<\delta$ and $i_1>0$, whence $i_1=\delta-t$; while N passes from E to R, $0<t<\delta$ and $i_1>0$, whence $i_1=\delta-t$; after N passes R, $0<\delta<t$ and $i_1<0$, whence as long as R lies within the range of transmission $i_1=\delta-t$. When N has passed 90° beyond R, to the position N_2, the vertex lies at R and light then ceases to fall on the face under consideration. Meanwhile, light has become incident on the other face of the angle, when its normal N' was in the position N'_2; as soon as R comes within the range of transmission, $t<0<\delta$ and $i_1<0$, whence $i_1=t-\delta$ until N' reaches E; while N' passes

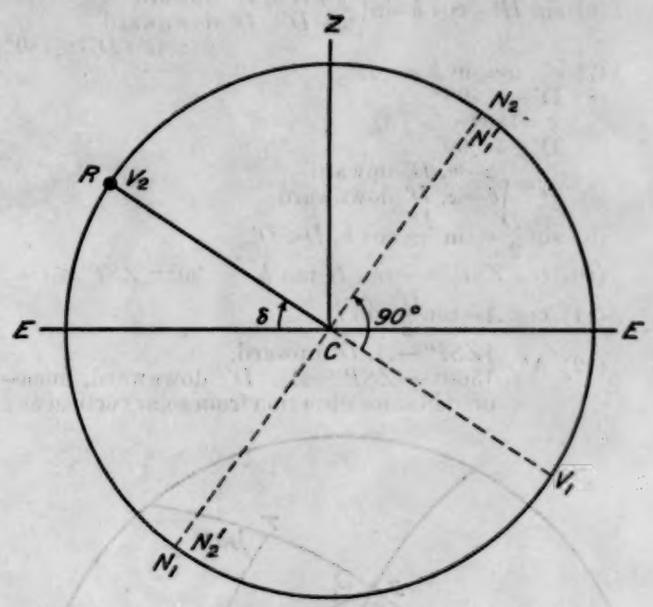


FIGURE 14. Determination of i_1 when refracting edge is horizontal.

from E to R, $0<t<\delta$ and $i_1<0$, whence $i_1=t-\delta$; after N' passes R, $0<\delta<t$ and $i_1>0$, whence $i_1=t-\delta$ until N' has passed 90° beyond R to N'_1. As the angle continues to turn, N, V again come into positions N_1, V_1, respectively, and the light once more becomes incident on the first face. That is, with the place of V given (90° in one of the two directions from N), we have for i_1:

	V, R on opposite sides of Z	V, R on same side of Z
Normal pointing up, t positive	$i_1=t-\delta$	$i_1=\delta-t$
Normal pointing down, t negative	$i_1=\delta-t$	$i_1=t-\delta$

The deviation D' is always toward V.

The position of the image is given by Formulae B; see figure 15.

FORMULAE B

CALCULATION OF THE IMAGE PRODUCED BY A DIHEDRAL REFRACTING ANGLE WITH HORIZONTAL REFRACTING EDGE

Parameters: H, $0°\leqq H\leqq 90°$; position of V; t (positive when normal is directed upward, negative when downward).

Argument: h (or, if desired, θ; then $\sin h=\sin\theta\cos H$; $0°\leqq\theta\leqq 90°$).

Calculation of D, A', $H'>0°$; ζ:

(1) $\sin\delta=\sin H\,\mathrm{sech}\,h$ $0°\leqq h\leqq(90°-H)$ or until total reflection occurs

(2) $\begin{cases} t>0; & V, R \text{ same side } Z \\ t<0; & V, R \text{ opposite sides } Z \end{cases}$

$$\sin r_1=\frac{1}{\mu}\sin(\delta-t)$$

Tables 2, 3

$\begin{cases} t>0;\ V, R \text{ opposite sides } Z \\ t<0;\ V, \text{R same side } Z \end{cases}$

$\sin r_1=\frac{1}{\mu}\sin(t-\delta)$

(3) $r'_1=\alpha-r_1$

(4) $\sin i'_1=\mu'\sin r'_1$ Table 3

(5) $D'=i_1+i'_1-\alpha$ from R toward V

(6) $\sin H'=\cos h\sin\begin{cases}(\delta+D'),\ D' \text{ upward}\\(\delta-D'),\ D' \text{ downward}\end{cases}$
$0°\leqq(\delta\pm D')\leqq180°$

(7) $\sin\omega=\sin h\sec H'$

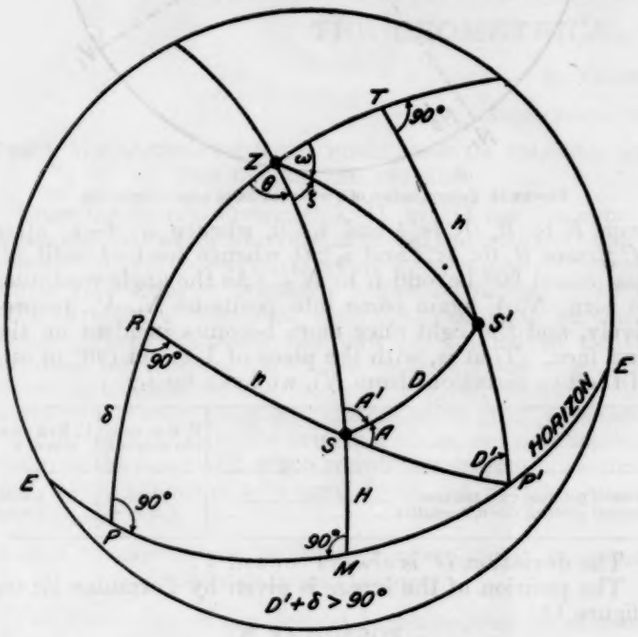
(8) $D'+\delta>90°$
$\zeta=180°-(\omega+\theta)$
$D'+\delta<90°$
$\zeta=\begin{cases}\omega-\theta,\ D' \text{ upward}\\\theta-\omega,\ D' \text{ downward}\end{cases}$

(9) $\sin\frac{D}{2}=\sin\frac{D'}{2}\cos h,\ D<D'$

(10) $\cos ZSP'=-\tan H\tan h$ $\quad 90°\leqq ZSP'\leqq180°$

(11) $\cot A=\tan\frac{D'}{2}\sin h$

(12) $A'=\begin{cases}ZSP'-A,\ D' \text{ upward},\\360°-(ZSP'+A),\ D' \text{ downward},\end{cases}$ measured in same direction from solar vertical as ζ



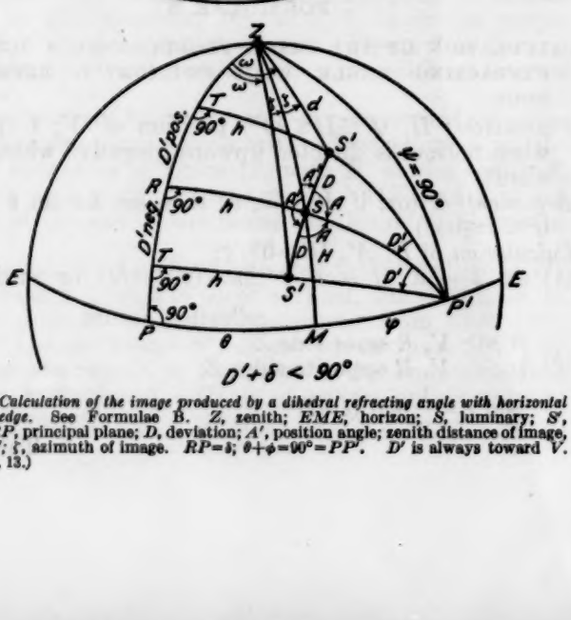


FIGURE 15. *Calculation of the image produced by a dihedral refracting angle with horizontal refracting edge.* See Formulae B. *Z*, zenith; *EME*, horizon; *S*, luminary; *S'*, image; *ZRP*, principal plane; *D*, deviation; *A'*, position angle; zenith distance of image, $d=90°-H'$; ζ, azimuth of image. $RP=\delta$; $\theta+\phi=90°=PP'$. D' is always toward V. (*Cf.* figs. 5, 13.)

[See figure 15. Formula (1) follows from the Law of Cosines applied to triangle *SZR*; (6) and (7) from the Law of Cosines and Law of Sines, respectively, in triangle *S'ZT*; (10) from Law of Cosines in *ZSP'*; the remaining formulae follow directly from either Formulae I or the geometry of figure 15.]

Images produced by a dihedral angle with the refracting edge in any position.—The superposition of figure 5 on the celestial sphere in an arbitrary orientation gives figure 16, from which Formulae C for the calculation of the image follow.

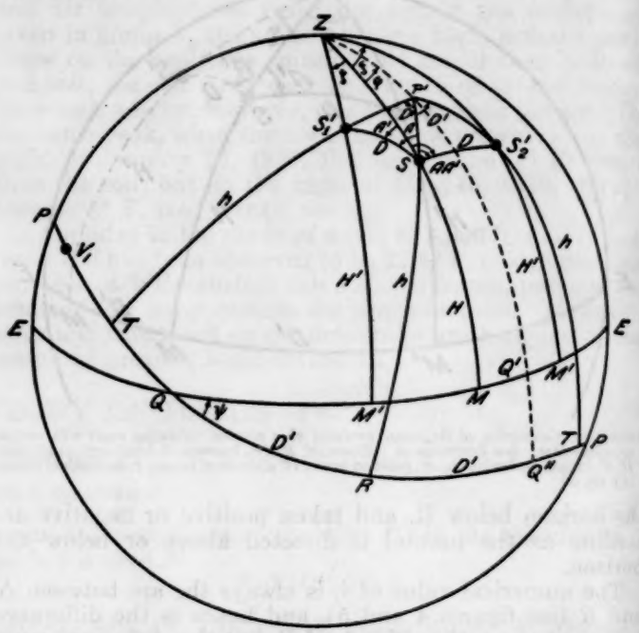


FIGURE 16. *Calculation of the image produced by a dihedral refracting angle with refracting edge in any position.* See Formulae C. *Z*, zenith; *EME*, horizon; *S*, luminary; *PRP*, principal plane; *P'*, pole of principal plane, specified by ψ, ϕ; S'_1, S'_2, images; *D*, deviation; ζ, azimuth of image. $ZP'=\psi$; $MQ=90°-\phi$; $QQ'=QQ''=90°$; D' is always toward *V*.

When $\psi=0°$, these formulae reduce to Formulae A; and when $\psi=90°$, they reduce to Formulae B.

FORMULAE C

CALCULATION OF THE IMAGE PRODUCED BY A DIHEDRAL REFRACTING ANGLE WITH REFRACTING EDGE IN ANY POSITION

Parameters: H, $0°\leqq H\leqq90°$; position of V
Arguments: ψ, ϕ
Calculation of D, A', H', ζ:

(1) $\tan m=\cos\phi\tan\psi$ $\quad 0°\leqq\phi\leqq90°,\ 0°\leqq\psi\leqq90°$

(2) $n=90°-(H+m)$

(3) $\sin h=\frac{\cos\psi\cos n}{\cos m}$

(4) $\tan ZSP'=\pm\frac{\tan\phi\sin m}{\sin n},\ H+m\leqq90°$

(5) Compute D', D, A from Formulae I

(6) $A'=A\pm ZSP'$

(7) $\tan m'=\cos A'\tan D,\ n'=90°-(H+m')$

(8) $\sin H'=\frac{\cos D\cos n'}{\cos m'}$

(9) $\tan\zeta=\pm\frac{\tan A'\sin m'}{\sin n'},\ H+m'\leqq90°$

[See figure 16. Formulae (1) to (4) constitute the solution of the triangle *ZP'S*, and (7) to (9), the solution of triangle *ZSS'*.]

NOTES AND REVIEWS

J. DURWARD, *Upper Winds at Wadi Halfa (Sudan)*. Meteorological Office Professional Notes No. 72. London. 1936. (*Abstract*).

Geographically, Wadi Halfa is located at 21° 55′ N., 31° 19′ E., height 421 feet; meteorologically it is between the high pressure system, which lies to the north over the desert west of Egypt throughout the year, and the Sudan pressure system to the south which undergoes a marked annual fluctuation.

Pilot balloon observations were begun at Wadi Halfa, which is the only such station between Cairo and Khartoum, in July 1934. The publication of a summary of the results after only a year of observation is considered to be justified in view of the fact that the pressure distribution varies so little throughout the year.

The surface wind rarely blows from any quarter other than the north at any time of the year and the upper winds are also characterized by great constancy of direction. The velocity and constancy are at a minimum between 5,000 and 6,000 feet. On about 17 occasions during the 12 months of observation, the wind at 2,000 feet was SE. to S.; the majority of southeasterly winds were due to a LOW, generally associated with a depression farther north over the western desert; in other cases, they were due to a northward extension of the Sudan LOW or to the small shallow depressions that form over the desert in May and October. In the former case the change from SE. to N. or NE. is nearly always accompanied by sandstorms but in the latter cases the wind is light and is not followed by any marked influx of cold air. Compared to the other levels, the winds at 2,000 feet are also the strongest. The highest velocities, considering all levels, occur in April and the lowest velocities in summer and autumn.

The wind from ground level up to a height of about 4,000 feet is nearly always between N. and NE. In the months of December to February the wind usually backs above this height to about WNW. at 10,000 feet and then continues without much change to 13,000. In July to September the backing is much greater, the wind becoming SW. to W. at 10,000 feet. In the transitional period March to June the wind does not as a rule back beyond north and particularly in June there is very little constancy of direction at high levels. The same applies to the winds during the second transitional period, October to November.

The annual variation of average wind speed at the four levels recommended by the International Commission for Air Navigation is:

Feet	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Range
1,500	19	21	19	20	16	17	15	15	23	19	16	17	8
3,000	18	22	22	26	19	19	19	18	27	21	18	19	9
6,000	15	17	17	23	16	16	17	12	12	12	10	15	13
10,000	22	18	22	21	13	14	16	12	16	9	13	14	13

Wadi Halfa is in the Nile Valley and therefore far removed from the northeast trades which would otherwise account for the constancy of the wind. The winds are therefore associated rather with the etesian winds of the Mediterranean and Egypt.

The observations at Wadi Halfa do not agree with the values expected from theoretical computations. In Shaw's Manual of Meteorology III, first edition, pages 259–265, the isobars indicate winds at about 90° variance to the observed wind directions except for the 2 km level in July, which agrees very well with the observed winds; a comment by Shaw on this discrepancy appears in Nature, May 29, 1937, page 926.—*C. M. L.*

L. WEICKMANN and K. KEIL, editors. *Results of the Aerological Ascents on International Days. International Polar Year 1932–33*. International Aerological Commission, Berlin SW. 11. Berlin, 1936.

This publication is now appearing in installments. At the moment the first two quarters of the year 1932 are available; when complete this work will consist of eight quarters.

This publication contains nearly all the upper air observations made in any part of the world on international days during the 2-year period. Never before has such an abundance of observations been brought together for the use of the investigator of the free air. The work consists entirely of numerical tables; the first three pages explain how to use the tables and as these are in German a translation is printed below:

EXPLANATIONS

In the publication of the results of aerological ascents of the time of the polar year, the observations are grouped according to the day on which they begin. In the year 1932, the following days were so-called "international days":

1932										
January	6	7	13	14	20	21	27	28		
February	3	4	10	11	17	18	24	25		
March	2	3	9	10	16	17	23	24	30	31
April	6	7	13	14	20	21	27	28		
May	4	5	11	12	18	19	25	26		
June	1	2	8	9	15	16	22	23	29	30
July	6	7	13	14	20	21	27	28		
August	3	4	10	11	17	18	24	25	31	
September	1	7	8	14	15	21	22	28	29	
October	5	6	12	13	19	20	26	27		
November	2	3	9	10	16	17	23	24	30	
December	1	7	8	14	15	21	22	28	29	

For each one of these days, the aerological observations are summed up in five groups, namely:

A. The measurements of pressure, temperature, and humidity in the free atmosphere.

From them are tabulated:

(1) Geopotential, temperature, and relative humidity at the principal isobaric surfaces ($\Phi\ TU/P$)

(2) Pressure, temperature, and relative humidity at specified geopotentials (PTU/Φ)

(3) Geopotential, pressure, temperature, and relative humidity of the outstanding points ($\Phi\ PTU$)

B. The measurements of upper winds according to direction and velocity for definite geopotentials (dv/Φ)

C. Additional observations to the measurements under A and B; observations of clouds and observations at mountain stations.

In the parts A and B, symbols are used at the headings of the tables and signify:

Φ = Geopotential (in dynamic meters).
T = Temperature (according to tercentesimal scale).
U = Relative humidity (in percent).
P = Pressure (in millibars).
G = Time of observation (according to Greenwich mean time G. M. T.).
d = Wind-direction (in degrees; 90 = east, 180 = south, 270 = west, 360 = north, 0 = calm).
v = Velocity (in meters per second).

A period (.) before the name of a place indicates that for the observation concerned, complementary observations are to be found in part C.

A star (*) signifies that in place of dynamic meters, geometric meters have been employed (height instead of geopotential).

Under the observations of part C are entered:

(a) Additional observations to part A. Therein belong:
(1) Data on the wind at the surface.
(2) Data on amount of clouds, cloud type, cloud direction, and cloud height.
(3) Data on technical details of the registering balloons. In that connection the following abbreviations have been employed:

Akg = Weight of the balloon in kilograms.
Afa = Free lift of the balloon in kilograms.
Jty = Type of meteorograph used.

Jkg=Weight of the meteorograph used including accessories (basket, cords, parachute, and the like), in kilograms.
Akm=Distance of the starting place from the landing place in kilometers.
Ad=Direction from the landing place to the starting place (given in degrees as in (*d*)).

(*b*) Additional observations for part B. Therein belong besides the above-named date under (*a*) 1 and 2, primarily data on the wind at natural levels.

(*c*) Cloud observations from such stations which have provided no measurements for group A or B. The data proceed in the same form as was described under (*a*) 1 and 2.

(*d*) Observations at mountain stations. These observations are set off by the symbol M before the name of the station. They give pressure (reduced to standard gravity and 0° C.), temperature, and relative humidity; thereafter data on wind and clouds as explained under (*a*) 1 and 2.

The following abbreviations are used for the kinds of clouds:

Ci=Cirrus.	Ac=Altocumulus.
As=Altostratus.	Sc=Stratocumulus.
St=Stratus.	Cb=Cumulonimbus.
Ns=Nimbostratus.	Cc=Cirrocumulus.
Cs=Cirrostratus.	Cu=Cumulus.

The star (*) before the name of the place is used in the meaning above-mentioned (height instead of geopotential).

There follow now examples of the data in part C.

(*a*) Dallas 1351 158/2; 1 Ci 315/5, 1 Ac 315 (4200); Akg 0.92; Afa 0.6; Jty Fergusson; Jkg 0.2; Akm 106; Ad 65
Means: Observation at Dallas at 13:51: Wind at the surface from direction 158, velocity 2m/sec; 1/10 Cirrus from direction 315, angular velocity 5, 1/10 altocumulus from direction 315, cloud height 4,200 gdm. The weight of the balloon used was 0.92 kg; the free lift 0.6 kg; the instrument of the Fergusson type weighed 0.2 kg; the starting place was 106 km distant from the landing place and lay in direction 65° from it.

(*b*) Blue Hill 1240 201–801: 290/14; 801–1524: 300/16; 1524–2582: 290/12; 3200: 280/22; 1 Ac 280/10 (4000), Sc (1150)
Means: Observation at Blue Hill at 12:40: Wind at level from 201 to 801 gdm from direction 290° at 14 m/sec; in the level from 801 to 1,524 gdm from direction 300° at 16 m/sec; in the level from 1,524 to 2,582 gdm from direction 290° at 12 m/sec; wind in 3,200 gdm from direction 280° at 22 m/sec; 1/10 altocumulus coming from direction 280°, angular velocity 10, height of the altocumulus 4,000 gdm, stratocumulus lie at 1,150 gdm.

(*c*) Aviano 1300 7 Ac —/3, Cu 270 (900)
Means: Observation at Aviano at 13:00: 7/10 altocumulus, direction not known, angular velocity 3, cumulus from direction 270 blowing at 900 gdm height.

(*d*) M Obir 0600 796.7 74.4 73; 2 Cc 270, Sc 270
Means: Observation at the mountain station Obir at 6:00: pressure: 796.7 mb, temperature 74.4°, relative humidity 73 percent; 2/10 cirrocumulus coming from direction 270°, stratocumulus likewise from 270°.

In this publication the following symbols are employed:
P=Pressure in millibars (mb).
T=Temperature in degrees of the tercentesimal scale (temperature in centesimal degrees plus 270°. minus 200°).
U=Relative humidity in percent.
Geopotential in geodynamic meters.
d=Wind direction in 360°.
v=Wind velocity in meters/second (m/sec).
G=Time in mean Greenwich time (M. G. T.).
Cloud-drift direction in 360°, as wind direction, cloud-drift velocity in angular velocity (1,000 v/h).
Weight in kilograms.
Distance in kilometers.

The arrangement of the individual stations proceeds according to regions, as below:
Region A=North and Central America.
Region B=South America.
Region C=Europe, North Africa, Siberia.
Region D=India and East Africa.
Region E=West and South Africa.
Region F=Australia and Oceania.
Region J=Japan and China.

Within each region, the stations lying farthest north always begin at the same north latitude, the station lying farther west comes first.

An index of all contributing stations with coordinates makes up the conclusion of the 1932 annual of this publication.

Special comment on the sounding balloon observations made in the United States during this period is in order. Sounding balloon observations were not made on each one of the international days but only on the days as shown in the table below. It should be emphasized that the figures in the third column represent the number of sounding balloons released and not the number of instruments returned.

Day	Number of balloons released	Day	Number of balloons released	Day	Number of balloons released
1932		*1932*—Contd.		*1933*—Contd.	
Aug. 10	3	Dec. 15	6	Apr. 26	3
Aug. 11	6	Dec. 28	3	Apr. 27	6
Aug. 24	3	Dec. 29	6	May 10	3
Aug. 25	6			May 11	6
Sept. 14	3	*1933*		May 24	3
Sept. 15	6	Jan. 11	3	May 25	6
Sept. 17	1	Jan. 12	6	June 7	3
Sept. 28	3	Jan. 25	3	June 8	6
Sept. 29	6	Jan. 26	6	June 21	3
Oct. 5	1	Feb. 8	3	June 22	6
Oct. 12	3	Feb. 9	6	July 12	3
Oct. 13	6	Feb. 22	3	July 13	6
Oct. 26	3	Feb. 23	6	July 26	3
Oct. 27	6	Mar. 8	3	July 27	6
Nov. 9	3	Mar. 9	6	Aug. 9	3
Nov. 10	6	Mar. 22	2	Aug. 10	6
Nov. 23	3	Mar. 23	5	Aug. 23	3
Nov. 24	6	Apr. 12	3	Aug. 24	6
Dec. 14	3	Apr. 13	6		

In all previous sounding balloon campaigns made in the United States by the Weather Bureau the detailed results of the observations have been published in a Weather Bureau publication. The sounding balloon observations of these 2 years in the United States make an exception as the detailed results are available only in the publication here being reviewed.—*Richmond T. Zoch.*

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[RICHMOND T. ZOCH, *in Charge of Library*]

By AMY D. PUTNAM

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SOLAR OBSERVATIONS

NOTE ON THE DETERMINATION OF THE TRANSMISSION OF COLOR SCREENS EMPLOYED IN SOLAR RADIATION INTENSITY MEASUREMENTS FOR THE COMPUTATION OF ATMOSPHERIC TURBIDTY FROM WHICH THE WATER VAPOR CONTENT OF THE ATMOSPHERE IS DETERMINED.

By H. H. KIMBALL, Research Associate, Harvard University

Ångström, and also Feussner, have called attention to the fact that different samples of the Schott-glass filters OG_1 and RG_2 vary somewhat among samples of the same color. The cut-off curve in the shorter wavelength end of the spectrum is very steep, and the wave lengths between which it occurs vary somewhat with temperature as well as with the individual screens examined. Ångström advises that this cut-off curve should be determined for each screen employed, as this would help to determine the transmission of the screen as a whole.

So far as I am aware, this has not generally been done. After Hoelper wrote me that American atmospheric turbidity determinations did not seem to be in accord with European determinations, an attempt was made to determine the transmission of screens that have been

employed at Blue Hill and Washington. In this work, the National Bureau of Standards has been most helpful, especially through the determination of the cut-off curves of samples of yellow and red Schott glass that they believed to be similar in character to screens employed in our regular published measurements.

It was hoped that from these measurements the transmission of our own screens could be determined with the required accuracy. During the month just passed a great deal of time was consumed in trying out different combinations of transmissions in the hope that a combination would be found that would seem to be adapted to Blue Hill screens.

Dr. Brooks computed, from the tests made with the Bureau of Standards' screens, the transmission of the yellow screen to be 0.868, and that of the red screen to be 0.833. When these coefficients were applied to Blue Hill measurements, the results obtained were unsatisfactory.

The results obtained from the transmission coefficients employed by Mr. Hand in reducing measurements obtained at Washington (see this REVIEW for April, 1937, p. 156), also were inadequate when applied to Blue Hill measurements. A great many combinations of transmission coefficients were then tried out, with the result that with a value very close to Dr. Brooks' computed value for the yellow screen, or 0.863, and a transmission coefficient of 0.852 for the red screen, fairly consistent results were obtained.

Commencing with the seventeenth, in the table for May, which accompanies this note, the values of β computed from the differences, $I_m - I_r$, and also from the differences, $I_y - I_r$, are given in the columns headed $\frac{I_y}{.851+c}$ and $\frac{I_r}{.840+c}$. While the results are not all that could be wished, neither set of values is persistently higher than the other, so that it seems fair to assume that some of the irregularities are due in part, at least, to irregularities in the sky conditions during the time the measurements were being made.

This assumption is supported by notes on sky conditions during solar observations. The sky on the twenty-first, twenty-fourth, and thirty-first was unusually free from haze, and the differences between the two sets of β values were not great.

It is hoped that at some time in the not distant future it will be possible to obtain accurate determinations of the cut-off curves of the glass screens OG_1 and OR_2 now in use at Blue Hill, without too much interruption to the observational program.

SOLAR RADIATION OBSERVATIONS DURING MAY 1937

By IRVING F. HAND, Assistant in Solar Radiation Investigations

For a description of instruments employed and their exposures, the reader is referred to the January, 1935 REVIEW, page 24.

Table 1 shows that solar radiation intensities averaged above normal for May at Washington and Madison, and below normal at Lincoln and Blue Hill. Although there was an appreciable amount of dust in the atmosphere at Lincoln, the skies for May at that station showed a decided improvement over those of the preceding month.

Whereas nearly all stations showed a deficiency in the amount of total solar and sky radiation during April, table 2 shows an excess at all stations for May with the exceptions of Riverside and Ithaca.

Table 3 shows an increase in the moisture content of the atmosphere over any preceding month of the year.

Polarization observations made at Washington on 8 days give a mean of 58 percent with a maximum of 64 percent on the eleventh. At Madison, observations made on 6 days give a mean of 56 percent with a maximum of 62 percent on the nineteenth. All of these values are close to the corresponding normals for the month.

TABLE 1.—*Solar radiation intensities during May 1937*

[Gram-calories per minute per square centimeter of normal surface]

WASHINGTON, D. C.

Date	Sun's zenith distance: 8 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.				*1.0	P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0		2.0	3.0	4.0	5.0	e
	mm	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
May 1	5.16	.....	0.88	1.04	1.20	1.44	.....	.....	.....	.....	3.45
May 2	7.29	.....	.....	.....	.....	1.40	.....	.....	.....	.....	6.02
May 3	5.36	.....	.....	1.07	1.23	1.42	.....	.....	.....	.....	3.63
May 4	6.76	0.72	.88	1.03	1.22	1.44	1.13	.....	.....	.....	4.37
May 7	6.02	.54	.70	.90	1.06	1.40	.....	.....	.....	.....	6.27
May 10	8.81	.....	.....	.....	.....	1.46	.64	.....	.....	.....	5.36
May 11	5.56	.....	.....	.....	1.23	1.44	1.09	.....	.....	.....	4.37
May 21	7.29	.....	0.94	1.04	1.20	.....	.....	.....	.....	.....	6.27
Means	.....	(.63)	.85	1.02	1.19	1.43	.95	.....	.....	.....	.....
Departures	.....	.00	+.13	+.18	+.18	+.15	+.02	.....	.....	.....	.....

MADISON, WIS.

May 5	5.56	.....	.....	0.94	1.25	1.56	.....	.....	.....	.....	9.47
May 6	4.75	.....	.....	1.10	1.30	1.49	.....	.....	.....	.....	5.56
May 7	5.79	.....	.....	.....	1.12	1.43	.....	.....	.....	.....	4.95
May 8	7.04	.....	.....	.....	1.18	1.45	.....	.....	.....	.....	6.76
May 10	6.02	.....	0.82	.87	1.14	1.42	.....	.....	.....	.....	6.27
May 12	10.21	.....	.....	.....	.....	1.28	.....	.....	.....	.....	10.59
May 17	5.79	.....	.92	.....	1.30	1.47	.....	.....	.....	.....	6.02
May 19	5.16	.....	.84	.....	1.37	1.54	.....	.....	.....	.....	6.76
May 28	10.59	.....	.....	.....	.....	1.40	.....	.....	.....	.....	11.38
Means	.....	.....	.86	.97	1.24	1.45	.....	.....	.....	.....	.....
Departures	.....	.....	+.04	+.06	+.13	+.08	.....	.....	.....	.....	.....

LINCOLN, NEBR.

May 5	7.87	.....	0.60	0.75	.....	.....	.....	.....	.....	.....	8.18
May 6	7.04	0.50	.55	.61	0.85	.....	.....	.....	.....	.....	5.79
May 7	7.57	.....	.65	.79	1.07	.....	.....	.....	.....	.....	6.76
May 12	7.29	.63	.81	.95	1.14	1.48	.....	.....	.....	.....	6.76
May 15	8.81	.....	.....	.66	.95	.....	.....	.....	.....	.....	10.59
May 17	4.48	.....	.....	.....	1.03	.....	.....	.....	.....	.....	9.47
May 18	10.21	.....	.....	.45	.86	.....	0.96	0.71	0.56	0.43	10.59
May 22	9.14	.....	.....	.....	1.28	.....	.....	.....	.....	.....	6.02
May 26	12.68	.....	.....	.....	.....	.....	1.19	1.03	.89	.78	13.61
May 27	9.83	.....	.....	.....	.....	.....	.....	.....	.88	.67	12.24
May 28	14.10	.....	.....	.....	.98	.....	.....	.....	.....	.....	15.65
May 29	13.13	.65	.78	.95	1.19	1.40	.....	.....	.....	.....	13.61
Means	.....	.59	.68	.74	1.04	(1.44)	(1.08)	(.87)	(.78	.63	.....
Departures	.....	−.06	−.10	−.18	−.07	+.06	−.02	−.03	−.02	−.04	.....

BLUE HILL, MASS.

May 1	4.2	0.54	0.90	1.04	1.21	1.41	1.18	1.05	0.80	.....	3.0
May 2	4.0	.....	.92	1.04	1.17	1.43	1.18	.96	.78	.....	3.6
May 3	4.4	.....	1.00	1.18	1.17	1.33	1.12	.93	.83	0.60	3.6
May 4	6.3	.....	.....	.....	.....	1.28	1.02	.89	.78	.....	3.0
May 9	7.3	.....	.....	.....	.....	1.34	1.12	.78	.....	.....	5.1
May 10	6.3	.....	.....	.....	1.00	1.14	1.03	.....	.....	.....	5.5
May 11	4.2	.....	.....	.96	1.13	1.38	1.10	.....	.....	.....	4.4
May 12	6.1	.....	.....	.92	1.12	1.35	.....	.....	.....	.....	4.8
May 16	5.6	.....	.....	.....	1.12	1.43	1.13	.....	.....	.....	5.1
May 17	5.6	.....	.....	.....	.....	1.31	1.02	.....	.....	.....	5.3
May 18	6.8	.....	.....	.88	1.00	1.16	.....	.....	.....	.....	6.6
May 21	7.1	.....	.....	.96	1.18	1.45	.....	.....	.....	.....	5.8
May 23	10.1	.....	.....	.....	.....	1.05	.....	.....	.....	.....	11.5
May 24	7.9	.....	.....	.96	1.13	1.33	.....	.....	.....	.....	7.5
May 25	7.9	.....	.....	.....	1.11	1.34	1.14	.....	.....	.....	7.7
May 29	11.5	.....	.....	.....	.....	1.20	1.04	.....	.....	.....	10.5
May 30	11.9	.....	.....	.....	1.05	1.32	.....	.....	.....	.....	8.4
May 31	11.5	.....	.....	.....	1.00	1.20	.90	.78	.....	.....	10.4
Means	.....	.54	.94	.99	1.11	1.30	1.08	.90	.80	.60	.....
Departures	.....	−.27	−.05	−.09	−.02	−.07	+.01	+.01	.00	−.16	.....

* Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Fairbanks	Twin Falls	La Jolla	New Orleans	Riverside	Blue Hill	San Juan	Friday Harbor	Ithaca
	Gram-calories per square centimeter														
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Apr. 30	686	398	457	391	582	693	463	590	554	485	586	623	527	597	455
May 7	614	543	537	562	435	698	496	568	552	467	531	422	540	403	385
May 14	481	492	508	427	376	744	570	609	540	604	590	356	620	523	262
May 21	500	468	617	392	507	634	396	651	262	551	316	495	463	513	407
May 28	518	546	528	517	415	741	459	545	405	515	458	576	549	709	550
	Departures from weekly normals														
Apr. 30	+220	−39	−17	−10	+179	+60	+73	+70	.....	+89	+18	+239	.....	+36	+120
May 7	+160	+95	+89	+136	+43	+50	+44	−20	.....	+73	−10	+44	.....	−138	−88
May 14	+9	+10	−15	−39	−41	+68	+102	−13	.....	+205	+23	−4	.....	+3	−207
May 21	−7	−23	+62	−97	+56	−38	−50	+6	.....	+141	−191	+65	.....	−27	−161
May 28	−6	+48	+17	+16	−43	+57	+43	−31	.....	+19	−82	+170	.....	+182	−19
	Accumulated departures on June 21														
	−469	−630	−1,659	+49	+2,919	+2,940	+903	+1,344	.....	+7,294	−2,205	+315	.....	+1,267	−1,632

TABLE 3.—*Total, I_m, and screened, I_v, I_r, solar radiation intensity measurements, obtained during May 1937, and determinations of the atmospheric turbidity factor, β, and water-vapor content, w=depth in millimeters, if precipitated. American University, Washington, D. C.*

Date and hour angle	Solar altitude	Air mass	I_m	I_v	I_r	$\beta_{I_{m-r}}$	$\beta_{I_{v-r}}$	β_{m+v}	$\frac{I_{m-r}}{1.94}$ Percentage of solar constant	$\frac{I_{v-r}-I_m}{1.94}$ Percentage of solar constant	w	Air-mass type
1937	° ′	*m*	*gr. cal.*	*gr. cal.*	*gr. cal.*						*mm*	
May 1:												
4:14 a. m.	29 56	2.00	1.197	0.848	0.713	0.061	0.111	0.086	66.2	3.5	1.0	Pc; S aloft.
4:11 a. m.	30 32	1.96	1.197	.848	.713	.064	.116	.090	66.1	3.5	1.0	
3:21 a. m.	40 04	1.55	1.287	.932	.746	.068	.056	.062	76.7	9.3	7.2	
3:17 a. m.	40 39	1.53	1.303	.932	.746	.060	.062	.061	76.7	8.5	4.5	
1:05 a. m.	62 16	1.13	1.390	.942	.760	.052	.100	.076	79.5	7.3	3.8	
1:00 a. m.	62 49	1.12	1.465	.942	.760	.044	.100	.072	79.9	6.4	3.0	
May 2:												
1:50 a. m.	55 42	1.21	1.262	.896	.711	.086	.082	.084	77.1	11.0	18.0	Pa; S aloft.
1:48 a. m.	56 00	1.20	1.253	.896	.711	.096	.086	.091	76.7	11.1	18.5	
May 3:												
3:50 a. m.	34 52	1.75	1.282	.919	.721	.038	.028	.033	79.6	12.6	23.0	Pc; Npa → S aloft.
3:47 a. m.	35 32	1.72	1.293	.919	.721	.036	.032	.034	79.7	12.1	17.6	
May 4:												
4:16 a. m.	30 07	2.00	1.217	.881	.717	.054	.068	.061	72.0	8.2	3.7	Npa; S aloft.
4:13 a. m.	30 37	1.96	1.205	.881	.717	.062	.068	.065	71.9	8.8	4.6	
3:31 a. m.	38 43	1.60	1.300	.932	.743	.051	.051	.051	77.4	9.4	6.9	
3:28 a. m.	39 18	1.58	1.297	.932	.743	.054	.054	.054	77.3	9.4	7.1	
2:53 a. m.	45 52	1.40	1.316	.943	.747	.068	.048	.058	79.7	10.8	14.2	
2:50 a. m.	46 26	1.38	1.334	.943	.747	.052	.050	.051	79.8	10.9	14.6	
May 7:												
4:56 a. m.	22 47	2.57	.927	.725	.602	.106	.098	.102	57.7	8.9	3.9	Npc; S aloft.
4:53 a. m.	23 22	2.51	.948	.725	.602	.100	.104	.102	58.3	8.4	3.6	
3:32 a. m.	39 04	1.58	1.133	.828	.668	.102	.100	.101	68.8	9.3	6.7	
3:28 a. m.	39 49	1.56	1.140	.828	.668	.101	.103	.102	68.8	8.9	5.9	
1:42 a. m.	58 40	1.17	1.283	.920	.727	.097	.073	.084	77.7	10.4	14.1	
1:37 a. m.	59 28	1.16	1.268	.920	.727	.103	.073	.088	76.8	10.3	13.9	
0:50 a. m.	65 23	1.10	1.362	.965	.760	.074	.070	.072	80.7	9.3	8.4	
0:46 a. m.	65 47	1.09	1.365	965	760	072	.070	.071	80.7	9.2	8.2	
May 10:												
0:05 p. m.	68 42	1.07	1.422	.982	.774	.046	.044	.045	84.8	10.1	15.0	Npc; S aloft.
0:09 p. m.	68 38	1.07	1.436	.982	.774	.038	.044	.041	84.8	9.2	8.8	
1:54 p. m.	57 19	1.19	1.361	.933	.751	.058	.088	.073	79.2	7.7	4.5	
1:59 p. m.	56 29	1.20	1.357	.953	.751	.060	.066	.072	79.2	7.9	4.5	
May 11:												
4:20 a. m.	30 23	1.96	1.232	.882	.711	.052	.060	.056	72.8	7.5	3.2	Npc.
4:16 a. m.	31 10	1.93	1.279	.882	.711	.048	.064	.056	73.0	8.4	3.7	
3:59 a. m.	34 21	1.77	1.270	.931	.739	.060	.036	.048	76.3	10.1	9.3	
3:56 a. m.	35 04	1.74	1.280	.931	.739	.054	.040	.047	76.7	9.9	8.8	
3:09 a. m.	44 05	1.44	1.378	950	758	056	.048	.052	78.8	9.1	6.1	
3:05 a. m.	44 50	1.41	1.343	.950	.758	.056	.054	.055	78.9	8.9	5.7	
1:50 a. m.	58 11	1.19	1.381	.986	.770	.060	.018	.039	84.0	12.0	27.2	
1:47 a. m.	58 40	1.17	1.403	.986	.770	.052	.020	.036	84.6	11.5	23.0	
3:41 p. m.	37 59	1.62	1.156	.830	.664	.088	.090	.089	70.8	10.4	10.4	
3:44 p. m.	37 24	1.64	1.161	.830	.664	.084	.086	.085	71.6	10.9	12.0	

May 1. Temp. 6 °C.; wind, NW., 7; polarization, 54 percent; visibility, 20 miles, blueness of sky, 5.
May 2. Temp. 9 °C.; wind, SE., 8; polarization, 56 percent; visibility, 30 miles, blueness of sky, 5.
May 3. Temp. 8 °C.; wind, N., 8; polarization, 58 percent; visibility, 30 miles, blueness of sky, 6.
May 4. Temp. 10 °C.; wind, SE., 9; polarization, 62 percent; visibility, 50 miles, blueness of sky, 7.
May 10. Temp. 5 °C.; wind, N., 10; polarization, 52 percent; visibility, 30 miles, blueness of sky, 5.
May 11. Temp. 9 °C.; wind, S., 6; polarization, 64 percent; visibility, 50 miles, blueness of sky, 7.

Meteorological Conditions During Solar Observations, May 1937

Date	Time from local noon	Temperature °C.	Wind Beaufort	Visibility	Sky blue	Haze*	Cloudiness and remarks
May 1	3:15 a. m.	12.7	NE 4	9	7	1-W	
1[1]	2:29 a. m.	12.2	NE 4	9	8	1-W	Trace Cu.
1	2:09 a. m.	12.1	NE 3	8	8	1	Trace Cu.
1	0:36 p. m.	12.8	NE 3	9	8	1-NW	1 Ci.
2	3:56 a. m.	9.6	NE 5	8	8	0	3 Ci.
2	0:02 a. m.	9.9	NNE 6	9	8	0	3 Ci, Trace Ac.
2	4:31 p. m.	11.1	NNE 7	9	8	0-W	2 Ci., 1 Ac.
3	3:53 a. m.	14.4	NW 3	7	8	1	
3	0:22 a. m.	21.7	WSW 3	8	8	0	Trace Ci.
3	3:41 p. m.	25.6	NW 2	8	8	0	Trace Ci.
3	4:46 p. m.	26.6	NW 2	9	8	0	Trace Ci.
4	1:08 a. m.	25.0	W 3	8	8	0	Trace Ci., Trace Cu.
4	0:28 p. m.	25.7	W 3	8	8	0	Few Cu.
4	2:40 p. m.	26.4	WSW 3	8	8	0	Few Ci., Few Cu.
9	4:08 p. m.	19.9	WNW 1	7	8	0	1 Cu.
9	5:13 p. m.	19.6	SE 3	7	8	0	2 Cu.
10	3:47 a. m.	11.1	SSW 3	8	7	0	2 Ci, 6Ac.
10	3:23 p. m.	15.5	W 4	8	7	0	2 Ci. 5 Cu.
11	3:54 a. m.	7.8	W 5	8	8	0	1 Ci., Trace Cu.
11	0:36 a. m.	13.3	WNW 5	8	8	0	1 Ci., Trace Cu.
11[1]	0:23 p. m.	14.4	NW 4	8	8	0	Trace Ci., 1 Cu.
11	2:41 p. m.	17.2	NNW 5	9	8	0	6 Cu.
12	3:54 a. m.	17.9	S 3	7	8	1	Trace Ci.
12[1]	3:11 a. m.	20.1	S 3	7	8	1	Trace Ci., Ci., increasing.
12	2:56 a. m.	20.7	S 3	7	8	1	1 Ci.
May 16	4:32 a. m.	8.2	W 3	8	8	0	3 Cicu.
16	0:05 p. m.	16.1	SE 1	9	8	0	2 Cicu.
16	2:59 p. m.	18.1	E 3	9	8	0	3 Ci.
17	2:41 p. m.	16.7	S 5	8	7	0	Few Ci., 2 Cu.
17	2:52 p. m.	16.7	S 5	8	7	0	2 Cs, Trace Cu.
18	4:32 a. m.	10.6	SSW 4	8	7	0	2 Ci., 4 Ac., Ci. over sun.
21	4:57 a. m.	11.1	NW 4	9	8	0	Trace Ci., Trace Ac.
21[1]	3:17 a. m.	13.9	WNW 3	9	8	0	1 Cu. Cu. within 2° of sun; Error due to wrong setting of watch or Cu. near sun.
21	2:58 a. m.	14.4	WNW 3	9	8	0	2 Cu.
21	0:31 a. m.	16.7	NW 3	9	8	0	Few Ci., Few Cu.
21[1]	0:21 a. m.	17.3	NW 3	9	8	0	Few Ci., Few Cu.
23	0:22 p. m.	19.5	NNW 1	6	7	2	Trace Ac.
23	3:17 p. m.	19.6	NE 3	6	6	2	5 Ci.
24	5:07 a. m.	12.9	WNW 3	7	8	1	1 Ac.
24	1:19 a. m.	19.2	WNW 3	8	8	0	Few Ac., Few Cu.
25	4:23 a. m.	14.5	WNW 5	8	7	0	Trace Ci.
29	2:44 p. m.	22.2	E 1	8	7	0-W	Trace Ci., 2 Cu.
30	0:46 p. m.	26.7	SW 1	8	7	-------	2 Ci., 2 Cu.
31	2:53 a. m.	23.3	SW 3	8	7	0	7 Ci., Thin Ci. over sun.
31	0:44 a. m.	28.3	SW 3	8	7	0	1 Ci.
31	0:22 a. m.	28.3	SW 3	8	7	0	1 Ci.

[1] Indicates Smithsonian Observation.

*Haze—0 Light; 1 Moderate; 2 Dense.

TABLE 3.—*Total I_m, and screened, I_y, I_r, solar radiation intensity measurements, obtained during May 1937 and determinations of the atmospheric turbidity factor, β, and water-vapor content, w=depth in millimeters, if precipitated*

BLUE HILL METEOROLOGICAL OBSERVATORY OF HARVARD UNIVERSITY

Date and hour angle, 1937	Solar altitude	Air mass	I_m	I_y	I_r	$\frac{I_y}{.851+C}$	$\frac{I_r}{.840+C}$	$\epsilon_{m,m}$ (*)	$\frac{I_{w=0}}{1.94}$ Percentage of solar constant	$\frac{I_{w=0}-I_m}{1.94}$ Percentage of solar constant	w	Air-mass type
May 1:	° ′	*m*	*gr. cal.*	*gr. cal.*	*gr. cal.*	*gr. cal.*	*gr. cal.*				*mm*	
3:13, a	40 58	1.51	1.246	0.793	0.650	0.964	0.787	0.076	73.1	7.8	6.3	Pc.
2:08, a	52 17	1.28	1.320	.850	.668	1.018	.806	.051	81.0	11.9	9.9	Np aloft.
0:37, p	62 40	1.11	1.400	.888	.710	1.059	.857	.068	81.2	8.0	7.6	
May 2:												
3:54, a	33 25	1.81	1.196	.798	.636	.975	.768	.048	71.8	15.5	11.5	
0:09, p	63 07	1.09	1.424	.893	.716	1.065	.865	.058	82.2	7.7	7.7	Pc.
4:34, p	25 30	2.32	1.108	.721	.580	.851	.684	.052	70.5	12.5	8.2	
May 3:												
4:20, a	28 51	2.29	1.234	.800	.666	.945	.805	.055	70.2	5.6	3.7	
0:19, a	63 08	1.12	1.320	.810	.666	.939	.805	.062	81.5	12.3	11.7	Npc; S aloft.
3:44, p	35 21	1.72	1.200	.772	.608	.895	.723	.072	72.0	8.1	6.2	
4:41, p	23 30	2.50	.998	.663	.536	.768	.637	.058	70.8	18.5	11.7	
May 4:												
1:06, a	59 55	1.15	1.228	.768	.618	.906	.727	.105	74.5	10.1	9.5	
0:34, p	61 30	1.14	1.244	.797	.640	.956	.774	.083	77.0	12.0	11.4	Npc.
2:37, p	47 22	1.48	1.159	.726	.590	.906	.727	.107	70.3	9.6	8.0	S aloft.
May 9:												
4:11, p	32 10	1.87	1.160	.734	.624	.867	.746	.128	62.5	11.8	8.7	Npa.
5:16, p	19 36	2.98	.734	.548	.460	.760	.558	.116	52.4	11.4	6.7	
May 10:												
3:44, a	35 40	2.30	.960	.640	.536	.655	.557	.136	50.5	4.7	3.1	Npc.
3:26, p	40 60	1.55	1.184	.770	.614	.912	.743	.098	61.9	8.1	6.4	Npp aloft.
May 11:												
3:51, a	35 36	1.71	1.184	.774	.637	.991	.772	.130	61.9	2.1	1.6	
0:35, p	64 32	1.10	1.356	.852	.686	1.009	.831	.084	70.9	6.6	6.4	Pc.
2:43, p	47 44	1.35	1.388	.818	.658	.969	.797	.050	85.0	12.4	10.8	
May 12:												
3:51, a	35 50	1.71	1.164	.762	.620	.900	.754	.088	76.0	15.1	11.6	Pc/s aloft.
2:59, a	46 45	1.36	1.292	.788	.640	.945	.777	.084	75.5	9.6	8.4	
May 16:												
4:29, a	40 08	1.55	1.272	.822	.660	.076	.048	.062	77.1	10.1	8.1	
0:08, p	67 12	1.09	1.424	.876	.712	.125	.009	.067	81.2	5.7	5.5	Npc.
3:02, p	45 25	1.40	1.312	.812	.670	.129	.030	.080	75.2	6.1	5.2	
May 17:												
2:43, p	48 55	1.32	1.214	-------	.612	-------	.071	-------	77.7	13.7	10.6	Npc/Npp aloft.
3:55, p	35 48	1.71	1.000	.720	.572	.100	.057	.078	71.1	3.7	2.8	
May 18:												
4:29, a	30 08	1.99	.988	.660	.548	.095	.016	.056	72.6	15.3	10.9	Npc/Npp aloft.
May 21:												
4:54, a	25 24	2.35	1.063	.744	.608	.049	.112	.080	64.7	7.5	3.3	
2:55, a	47 14	1.36	1.334	.860	.684	.097	.035	.066	78.6	8.1	6.1	Npc.
0:28, a	67 11	1.09	1.420	.896	.720	.110	.010	.060	82.6	7.6	7.3	
May 23:												
0:23, p	67 45	1.08	1.040	.696	.598	.216	.236	.226	64.5	9.5	9.3	Npa/Ta aloft.
3:29, p	45 15	1.40	.976	.640	.520	.164	.215	.190	65.1	13.6	11.6	
May 24:												
5:04, a	23 53	2.46	1.040	.700	.560	.157	1.149	.153	72.0	17.1	14.6	Npc/S aloft.
1:25, a	67 54	1.08	1.312	.808	.650	.192	.175	.184	80.0	10.8	10.5	
May 25:												
4:20, a	32 10	1.87	1.138	.733	.578	.061	.102	.082	71.2	5.7	3.1	Npc.
May 29:												
2:46, p	49 44	1.30	1.072	.684	.542	.040	.064	.052	80.7	23.9	10.1	Npc.
May 30:												
0:49, p	67 04	1.09	1.268	.784	.632	.039	.188	.114	75.4	16.7	14.4	Npc.
May 31:												
2:50, a	49 24	1.31	1.108	.700	.544	.075	.127	.101	73.5	14.8	13.1	
0:19, a	69 18	1.07	1.174	.728	.576	.076	.151	.124	74.7	12.5	12.1	Np.
3:00, p	47 26	1.35	1.084	.656	.528	.075	.146	.120	72.0	15.1	13.1	

* Corrected for transmission of screens and reduced to mean solar distance.

LATE REPORT

Summary of meteorological conditions during solar observations for March 1937

Date	Time from local noon	Temperature °C.	Wind-Beaufort	Visibility	Sky blue	Cloudiness and remarks
Nov. 1	3:02 a. m.	−4.4	W 3	7	8	Moderate to dense haze.
1	1:47 a. m.	−0.6	W 2	7	8	Do.
1[1]	1:38 a. m.	−0.3	W 2	7	8	Do.
1	0:08 p. m.	+2.2	WSW 2	8	8	Moderate haze.
1	2:13 p. m.	+4.4	WSW 3	8	8	Light haze.
1	3:13 p. m.	+4.4	WSW 4	7	8	Do.
2	3:35 a. m.	−1.6	W 3	6	8	1 Cu., Moderate haze.
2	0:51 a. m.	+3.9	W 3	7	8	1 Cl., Few Cu., Moderate haze.
3	3:41 a. m.	−3.3	NNW 3	7	8	Few Cu., Moderate haze.
3	1:09 a. m.	−0.3	NW 3	9	8	Few Cu., Light haze.
3	1:34 p. m.	+2.3	WNW 3	10	9	
3	3:03 p. m.	+2.7	NW 3	10	9	
7	3:16 a. m.	−9.7	NW 4	10	9	
7[1]	2:05 a. m.	−8.2	NW 4	10	9	
7	1:49 a. m.	−7.8	NW 4	10	9	
7	2:22 p. m.	−1.4	WNW 5	10	9	
10	3:06 a. m.	−8.3	W 4	9	8	Few Cl., Few Cu., Light haze to North.
10[1]	2:57 a. m.	−8.0	W 4	9	8	Do.
11	2:59 a. m.	−5.0	NW 3	3	3	
12	3:38 a. m.	−4.7	N 3	5	7	1 Acu., Dense haze.
12	1:24 p. m.	−2.2				Discontinued because of clouds.
12	2:23 p. m.	−2.2				Do.
14	0:44 a. m.	−1.8	NNW 2	6	7	1 Cl., Dense haze.
18	2:37 a. m.	+4.3	WSW 5	7	8	Few Acu., Moderate haze.
19	1:40 a. m.	+4.4	WSW 5	8	7	2 Acu., Few Cu., Moderate haze.
20	3:46 a. m.	+1.5	W 6	7	8	Few Cl., Few Acu., Moderate haze.
22	3:23 a. m.	+1.7	W 5	9	8	1 Cu., Light to moderate haze.
22	0:34 a. m.	+3.9	W 5	9	8	1 Cu., Light haze.
22	2:29 p. m.	+3.9	W 6	9+	8	1 Cu.
22	4:31 p. m.	+3.9	W 5	9+	8	Few Cu., Light haze.
23	3:23 a. m.	−2.2	W 3	8	8	Do.
24	4:08 a. m.	−2.2	W 2	7	7	Moderate haze.
24[1]	3:26 a. m.	−1.5	WSW 2	7	7	Do.
24	3:11 a. m.	−1.4	W 2	8	8	Do.
24	0:45 a. m.	+2.8	WSW 3	9	8	Few Cu., Light haze to North.
26	3:24 a. m.	−5.4	W 4	8	8	Few Cu., Light haze.
26[1]	3:12 a. m.	−5.0	W 4	8	8	Do.
26	0:53 a. m.	−2.2	W 4	9	8	Few Cl., 1 Cu.
27	3:33 a. m.	−0.6	W 5	8	8	2 Acu., Few Cu.
28	3:16 p. m.	+1.0	NW 5	10	8	3 Cu., 1 Ci.
28	4:38 p. m.	0.0	NW 4	10	8	2 Cl., Few Cu.
29	3:30 a. m.	−1.0	WNW 4	9	7	Few Cl., Few Acu. 3 Cu., 1 Stcu.
29	1:35 a. m.	+1.8	NW 4	10	8	Few Cl., Few Acu., Few Cu.
29[1]	1:21 a. m.	+2.4	NW 4	10	8	
29	1:50 p. m.	+7.2	W 4	10	7	Few Acu., Few Cu.
29	4:51 p. m.	+7.2	WNW 5	10	7	Few Cl., Few Acu.
30	3:31 a. m.	−0.5	WNW 4	9	8	Few Cu.
30	0:44 a. m.	+3.3	NW 4	10	7	
30	2:24 p. m.	+6.1	NW 4	10	7	
30	4:59 p. m.	+5.2	NW 4	10	7	
31	0:35 a. m.	+3.6	NNW 2	8	7	3 Cl., Moderate haze.
31	2:27 p. m.	+7.2	NE 1	9	7	3 Cl., Light haze Ci. passed on front of sun.
31	3:30 p. m.	+7.6	SE 1	9	6	2 Cl., Light haze.

[1] Denotes Smithsonian observation.

The vapor pressure at 8:00 p. m. March 31, 1937, was 2.9 mm.

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.), Superintendent U. S. Naval Observatory. Data furnished by the U. S. Naval Observatory in cooperation with Harvard and Mount Wilson Observatories. The difference in longitude is measured from the central meridian positive west. The north latitude is positive. Areas are corrected for foreshortening and are expressed in millionths of the sun's visible hemisphere. The total area for each day includes spots and groups]

Date	Eastern standard time	Heliographic			Area		Total area for each day	Observatory
		Diff. in longitude	Longitude	Latitude	Spot	Group		
1937	h m	°	°	°				
Apr. 1	11 16	−64.0	53.7	+10.0		97		U. S. Naval.
		−59.0	58.7	+22.0	97			
		−31.0	86.7	+15.5		194		
		−21.0	96.7	+ 8.5		73		
		− 7.5	110.2	− 9.0	73			
		+12.0	129.7	+10.0		97		
		+21.0	138.7	+ 9.5		242		
		+37.5	155.2	+11.0		48		
		+47.5	165.2	+ 9.5		145		
		+50.0	167.7	+ 7.5		194	1,260	
Apr. 2	11 17	−49.0	55.5	+10.0	48			Do.
		−44.0	60.5	+22.0	61			
		−18.0	86.5	+15.5		97		
		− 9.0	95.5	+ 9.5		36		
		+ 7.5	112.0	− 8.0	48			
		+20.0	130.5	+10.5		339		
		+34.5	139.0	+ 9.5		388		
		+60.0	164.5	+ 9.0	145			
		+63.0	167.5	+ 7.0	194		1,356	

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Heliographic			Area		Total area for each day	Observatory
		Diff. in longitude	Longitude	Latitude	Spot	Group		
1937	h m	°	°	°				
Apr. 3	10 23	−75.0	16.8	−21.5		194		U. S. Naval.
		−44.0	47.8	−14.5		48		
		−35.5	56.3	+10.0		48		
		−31.0	60.8	+22.0	73			
		− 4.0	87.8	+15.5		97		
		+ 5.0	96.8	+ 9.0		48		
		+ 5.5	97.3	− 9.5	24			
		+19.0	110.8	− 7.5	36			
		+35.0	126.8	+10.0		242		
		+41.0	132.8	+11.0		436		
		+50.0	141.8	+ 9.0		436		
		+72.0	163.8	+ 9.0	145			
		+76.0	167.8	+ 7.0	194		2,021	
Apr. 4	14 19	−59.0	17.4	−22.0	103			Harvard.
		−50.0	26.4	−20.0	125			
		−19.0	57.4	+ 9.5		161		
		−14.0	62.4	+23.0	84			
		+51.0	127.4	+12.0		207		
		+60.0	136.4	+13.0		411		
		+70.0	146.4	+10.0		347	1,438	
Apr. 5	10 46	−56.0	9.2	− 8.0		170		Mt. Wilson.
		−46.0	19.2	−21.0		436		
		− 9.0	56.2	+10.5		97		
		− 4.5	60.7	+21.0	73			
		+23.0	88.2	+15.0		145		
		+62.0	127.2	+10.0		291		
		+69.0	134.2	+11.0		485		
		+79.0	144.2	+ 9.0		388	2,085	
Apr. 6	10 56	−41.0	10.9	− 9.0		170		U. S. Naval.
		−33.0	18.9	−21.0		388		
		+ 9.0	60.9	+21.0	48			
		+ 9.5	61.4	+10.5	73			
		+33.0	84.9	+15.0	48			
		+39.0	90.9	+13.0		36		
		+75.0	126.9	+10.0		242		
		+83.0	134.9	+11.0		339	1,344	
Apr. 7	11 0	−32.0	6.7	− 7.0	16			Do.
		−27.5	11.2	− 9.0		145		
		−22.0	16.7	−21.0		242		
		−14.0	24.7	−20.5	194			
		+15.0	53.7	−13.5		24		
		+20.5	59.2	+21.0	24			
		+24.0	62.7	+10.5	24			
		+50.0	88.7	+14.5		97		
		+73.0	111.7	−30.5		97	863	
Apr. 8	10 32	−55.0	330.7	−26.5	6			Mt. Wilson.
		−19.0	6.7	−7.0		12		
		−15.0	10.7	+29.0		24		
		−14.0	11.7	−9.0		73		
		−10.0	15.7	−21.0		339		
		−1.0	24.7	−21.0	145			
		+9.0	34.7	+20.0		48		
		+37.0	62.7	+10.0	12			
		+61.0	86.7	+13.0		73	732	
Apr. 9	9 16	−5.0	8.2	−7.0		48		Do.
		0.0	13.2	−21.5		194		
		+1.0	14.2	−9.5		73		
		+4.0	17.2	+30.0		48		
		+6.0	19.2	−21.0		24		
		+9.0	22.2	+27.0	12			
		+12.0	25.2	−21.0	145			
		+21.0	34.2	−12.5		24		
		+23.0	36.2	+20.0		61		
		+51.0	64.2	+9.0	12			
		+73.0	86.2	+13.0		48	689	
Apr. 10	11 2	+14.0	13.1	−21.5		194		U. S. Naval.
		+17.0	16.1	−9.5		73		
		+18.0	17.1	+30.0		48		
		+26.0	25.1	−21.0	121			
		+39.0	38.1	+19.5		109	545	
Apr. 11	13 25	−4.0	340.5	+10.0		97		Do.
		+29.0	13.5	−22.0		145		
		+32.0	16.5	−10.0	48			
		+40.0	24.5	−21.5		97		
		+54.0	38.5	+19.0		194	581	
Apr. 12	11 1	−42.5	290.2	−11.5		73		Do.
		+8.0	340.7	+10.5		48		
		+40.0	12.7	−22.0		73		
		+44.0	16.7	−10.0	24			
		+51.5	24.2	−21.0		61		
		+66.0	38.7	+20.0		194		
		+68.5	41.2	−11.0	12			
Apr. 13	10 54	−29.0	290.5	−11.5		48		Do.
		+53.0	12.6	−22.5	48			
		+65.0	24.5	−21.0	97			
Apr. 14	10 51	+67.0	13.3	−23.0	73			Mt. Wilson.
		+70.0	16.3	−15.0	48			
		+79.0	25.3	−22.0	97		218	
Apr. 15	14 56	−70.0	220.9	+10.5	97			U. S. Naval.
		−20.5	270.4	−31.0		121		
		0.0	290.9	−11.0		97	315	
Apr. 16	12 26	−60.0	219.1	+10.0		170		Do.
		−31.0	248.1	−25.0		48		
		−9.0	270.1	−31.0		145		
		+12.5	291.6	−11.0		121	484	
Apr. 17	10 50	−48.0	218.7	+10.0		194		Do.
		+2.5	269.2	−30.5		121		
		+25.0	291.7	−10.0		121	436	
Apr. 18	11 21	−50.0	203.2	−9.5		109		Do.
		−36.0	217.2	+10.0		24		
		−30.0	223.2	+10.0	194			
		+15.0	268.2	−31.0		73		
		+38.5	291.7	−10.0		97	497	

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Heliographic			Area		Total area for each day	Observatory
		Diff. in longitude	Longitude	Latitude	Spot	Group		
1937	h m	°	°	°				
Apr. 19	11 7	−74.0	166.2	+9.5	145			U. S. Naval.
		−66.0	174.2	−16.5	97			
		−61.0	179.2	+20.5		48		
		−37.0	203.2	−9.5		436		
		−18.0	222.2	+10.0		97		
		+27.0	267.2	−31.0		48		
		+48.0	288.2	−10.5	48		919	
Apr. 20	11 13	−59.0	167.9	+9.0	97			Do.
		−51.0	175.9	−17.0	61			
		−51.0	175.9	+20.0		485		
		−33.0	193.9	+26.0		73		
		−24.0	202.9	−9.5		679		
		−4.0	222.9	+10.0	97			
		+60.0	286.9	−10.0	48		1540	
Apr. 21	9 12	−46.0	165.7	+9.5	121			Mt. Wilson.
		−40.0	171.7	−16.0	61			
		−39.0	172.7	+20.5		1261		
		−21.0	190.7	+26.0		339		
		−11.0	200.7	−9.5		582		
		+9.0	220.7	+10.5		97		
		+73.0	284.7	−10.5	97		2558	
Apr. 22	11 5	−31.0	169.6	+9.0	121			U. S. Naval.
		−26.0	174.6	−17.0	48			
		−25.0	175.6	+20.0		1648		
		−6.0	194.6	+26.0		873		
		0.0	200.6	+9.0		121		
		+3.0	203.6	−9.5		582		
		+21.0	221.6	+10.0	73		3466	
Apr. 23	11 21	−19.0	168.2	+9.5	73			Do.
		−11.5	175.7	+20.0		1648		
		−11.0	176.2	−16.5	48			
		+6.0	193.2	+26.0		873		
		+13.5	200.7	+9.0		170		
		+16.0	203.2	−9.5		485		
		+35.0	222.2	+10.0	61		3358	
Apr. 24	9 21	−6.0	169.1	+10.0	73			Mt. Wilson.
		0.0	175.1	−16.5	24			
		+1.0	176.1	+21.0		2085		
		+4.0	179.1	−9.5		36		
		+21.0	196.1	+26.0		1164		
		+27.0	202.1	+9.5		145		
		+29.0	204.1	−9.5		485		
		+31.0	206.1	−23.0		48		
		+39.0	214.1	+11.0		36		
		+49.5	224.6	+10.5		61	4157	
Apr. 25	9 15	−57.0	105.0	−21.0		88		Do.
		+6.0	168.0	+8.0	107			
		+11.0	173.0	+20.0		2274		
		+12.0	174.0	−16.0		5		
		+15.0	177.0	−10.0		70		
		+18.0	180.0	+10.0		34		
		+33.0	195.0	+24.0		1435		
		+39.0	201.0	+9.0		90		
		+40.0	202.0	−9.0		570		
		+44.0	206.0	−24.0		10		
		+61.0	223.0	+11.0	97		4780	
Apr. 26	12 31	−51.0	95.9	+21.0		73		Do.
		−41.0	105.9	−20.0		388		
		+3.0	149.9	+21.0		48		
		+23.0	169.9	+10.0	73			
		+28.0	174.9	+20.5		2279		
		+29.5	176.4	−11.0		291		
		+35.0	181.9	+11.0		121		
		+48.0	194.9	+27.0		1600		
		+55.0	201.9	+9.5		73		
		+56.0	202.9	−9.5		485	5431	
Apr. 27	11 40	−26.0	108.2	−20.0		727		U. S. Naval.
		+36.0	170.2	+10.0	48			
		+41.0	175.2	+19.5		1988		
		+43.0	177.2	−10.0		339		
		+49.0	183.2	+10.5		97		
		+60.0	194.2	+27.0		1164		
		+69.0	203.2	+9.5		388	4751	
Apr. 28	11 16	−13.0	108.2	−20.5		970		Do.
		+49.5	170.7	+10.0	61			
		+54.0	175.2	+19.5		1988		
		+57.0	178.2	−10.0		291		
		+75.0	196.2	+27.0		1309	4619	
Apr. 29	11 48	−70.0	37.7	+19.5	145			Do.
		+1.0	108.7	−20.5		970		
		+62.0	169.7	+10.0	97			
		+68.0	175.7	+19.0		2085		
		+70.5	178.2	−10.0		291	3588	
Apr. 30	11 14	−58.0	36.8	+19.5	194			Do.
		+14.0	108.8	−20.5		1018		
		+76.0	170.8	+10.0	97			
		+79.0	173.8	+19.0		1357	2666	
May 1	11 34	−44.5	36.9	+19.0	218			Do.
		+28.0	109.4	−20.5		921		
		+43.0	124.4	+10.0		48		
		+45.0	126.4	−19.0	24		1,211	
May 2	12 16	−30.0	37.8	+19.0	218			Do.
		+41.5	109.3	−20.5		873	1,091	
May 3	11 10	−18.0	37.2	+19.0		242		Do.
		+55.0	110.2	−20.5		873	1,115	
May 4	11 10	−80.0	321.9	+12.0		388		Do.
		−31.0	10.9	−12.0		48		
		−15.5	26.4	−18.0		36		
		−3.0	38.9	+19.0		339		
		+72.0	113.9	−20.5		873	1,684	

Mean daily area for 30 days, April, 1912,

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Heliographic			Area		Total area for each day	Observatory
		Diff. in longitude	Longitude	Latitude	Spot	Group		
1937	h m	°	°	°				
May 5	11 8	−67.0	321.7	+12.0		388		U. S. Naval.
		−20.0	8.7	−12.0		36		
		−3.0	25.7	−18.0	12			
		+9.0	37.7	+19.0		315		
		+14.0	42.7	+19.0		36		
		+81.0	109.7	−20.5		339	1,126	
May 6	11 1	−53.0	322.6	+11.0		339		Do.
		+10.0	25.6	−19.0	12			
		+22.0	37.6	+18.5		242		
		+29.0	44.6	+18.5	6		599	
May 7	11 17	−39.0	323.2	+11.0		339		Do.
		+35.0	37.2	+19.0		242		
		+41.0	43.2	+19.0	6		587	
May 8	11 1	−26.0	323.1	+11.5		388		Do.
		+49.0	38.1	+19.0		194	582	
May 9	11 24	−82.0	253.7	+19.0		582		Do.
		−63.0	272.7	+20.5	48			
		−45.0	290.7	+12.0	36			
		−21.0	314.7	−18.0		85		
		−11.0	324.7	+12.0		388		
		+61.0	36.7	+19.0	145		1,284	
May 10	11 0	−75.0	247.7	−31.0		145		Do.
		−68.0	254.7	+19.0		582		
		−49.5	273.2	+20.0	16			
		−36.0	286.7	+11.0		73		
		−8.0	314.7	−18.0		145		
		+2.0	324.7	+11.0	242			
		+22.0	344.7	+10.0		48		
		+75.0	37.7	+19.0	242		1,493	
May 11	11 23	−60.0	249.3	−32.0		145		Do.
		−55.0	254.3	+19.0		582		
		−36.0	273.3	+20.0	12			
		−23.0	286.3	+11.0		121		
		+3.0	312.3	−19.0		48		
		+11.0	320.3	−18.0		97		
		+16.5	325.8	+11.0	242			
		+36.0	345.3	+10.5		48	1,295	
May 12	11 12	−50.0	246.1	+19.0		97		Do.
		−48.0	248.1	−32.0		97		
		−38.0	258.1	+19.5		533		
		−22.0	274.1	+20.0	12			
		−11.0	285.1	+11.0		48		
		−5.0	291.1	+11.0		36		
		+16.0	312.1	−19.0		36		
		+26.0	322.1	−18.0	48			
		+30.0	326.1	+11.5	218			
		+49.0	345.1	+10.5		73	1,198	
May 13	10 50	−38.0	245.1	+19.0		97		Do.
		−35.0	248.1	−32.0		73		
		−24.0	259.1	+19.0		533		
		−10.0	273.1	+20.0	12			
		+38.0	321.1	−17.0	48			
		+42.0	325.1	+12.0	291			
		+60.0	343.1	+10.0	97		1,151	
May 14	8 29	−80.0	191.2	−15.0		145		Mt. Wilson.
		−79.0	192.2	−26.0	194			
		−67.0	204.2	−19.0	48			
		−66.0	205.2	−7.0	48			
		−25.0	246.2	+20.0		73		
		−22.0	249.2	−32.0		97		
		−11.5	259.7	+19.5		582		
		+49.5	320.7	−18.0		48		
		+56.0	327.2	+12.0	242			
		+75.0	346.2	+10.0	97		1,574	
May 15	11 21	−78.0	178.4	+28.0	339			U. S. Naval.
		−78.0	178.4	+19.0	145			
		−70.0	186.4	−15.0		679		
		−59.0	197.4	+24.0	97			
		−52.0	204.4	−19.0		97		
		−49.0	207.4	−7.0	24			
		−9.0	247.4	−32.0	48			
		−9.0	247.4	+19.0		36		
		+2.0	258.4	+19.0		436		
		+70.0	326.4	+11.0	242		2,143	
May 16	13 35	−74.0	167.9	+18.5		485		Do.
		−61.0	180.9	+28.0		242		
		−61.0	180.9	+19.0	121			
		−56.0	185.9	−16.0		873		
		−46.0	195.9	−17.0		242		
		−45.0	196.9	+24.0	48			
		−41.0	200.9	+20.5	12			
		−37.0	204.9	−19.0		121		
		+7.0	248.9	−31.0		36		
		+8.0	249.9	+19.0		48		
		+17.0	258.9	+19.5		582		
		+29.0	270.9	−16.0		48	2,858	
May 17	11 15	−61.0	169.0	+18.0		436		Do.
		−49.5	180.5	+28.0		242		
		−49.5	180.5	+19.0	97			
		−44.0	186.0	−15.0		873		
		−33.0	197.0	−16.0		194		
		−32.0	198.0	+23.0	48			
		−29.5	200.5	+21.0	12			
		−23.0	207.0	−19.5		121		
		+19.0	249.0	−30.0	24			
		+29.0	259.0	+20.0		533		
		+40.0	270.0	−17.0		145	2,725	
May 18	11 4	−80.0	136.9	+10.0		242		Do.
		−49.0	167.9	+18.5		533		
		−38.0	178.9	+28.0		194		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Heliographic			Area		Total area for each day	Observatory
		Diff. in longitude	Longitude	Latitude	Spot	Group		
1937	h m	°	°	°				
May 18	11 4	−37.0	179.9	+19.0	145			U. S. Naval.
		−28.0	188.9	−15.0		1,164		
		−20.0	196.9	+23.0	12			
		−11.0	205.9	−19.0		97		
		+30.5	247.4	−30.5	24			
		+41.0	257.9	+20.0		436		
		+54.0	270.9	−17.0		291	3,138	
May 19	10 39	−87.0	116.9	−19.5	242			Do.
		−65.0	138.9	+10.5		242		
		−35.0	168.9	+18.5		388		
		−25.0	178.9	+28.5	194			
		−24.0	179.9	+19.0	145			
		−14.0	189.9	−16.0		1,164		
		−7.0	196.9	+23.0	24			
		+2.5	206.4	−19.0		97		
		+43.0	246.9	−30.5	24			
		+53.0	256.9	+20.0		339		
		+65.0	268.9	−17.0		388	3,247	
May 20	11 10	−73.0	117.3	−19.5	291			Do.
		−51.0	139.3	+11.0		242		
		−21.0	169.3	+19.5		388		
		−11.0	179.3	+28.5	194			
		−10.0	180.3	+19.0	145			
		−1.0	189.3	−16.0		1,406		
		+7.0	197.3	+23.0	24			
		+13.0	203.3	−19.0		97		
		+67.0	257.3	+20.0		339		
		+80.0	270.3	−17.0		388	3,514	
May 21	11 7	−76.0	101.1	+12.0		970		Do.
		−60.0	117.1	−20.0	436			
		−38.0	139.1	+11.0		242		
		−10.0	167.1	+19.5		242		
		+0.5	177.6	+28.5		194		
		+1.0	178.1	+19.0	145			
		+12.0	189.1	−16.5		1,745		
		+19.0	196.1	+21.0		97		
		+28.0	205.1	−19.0		48		
		+81.0	258.1	+20.0		291	4,410	
May 22	11 42	−64.0	99.6	+12.0		873		Do.
		−46.0	117.6	−20.0	533			
		−39.0	124.6	+10.5		97		
		−27.0	136.6	+10.5		73		
		−21.0	142.6	+10.0	194			
		+6.0	169.6	+19.5		218		
		+14.0	177.6	+27.0		242		
		+16.5	180.1	+19.0	145			
		+25.0	188.6	−16.0		1,309		
		+32.0	195.6	+21.0		339		
		+41.0	204.6	−18.0		48	4,071	
May 23	9 59	−53.0	98.3	+13.0		921		Mt. Wilson.
		−35.0	116.3	−20.0	582			
		−27.0	124.3	+12.0		194		
		−14.0	137.3	+12.0		48		
		−10.0	141.3	+10.0		145		
		+19.5	170.8	+20.0		145		
		+27.0	178.3	+28.0		194		
		+29.5	180.8	+19.5	121			
		+40.0	191.3	−17.0		1,212		
		+48.0	199.3	+23.0		970		
		+57.0	208.3	−19.0		97	4,629	
May 24	11 9	−62.0	75.4	+6.0	12			U. S. Naval.
		−35.0	102.4	+12.0		776		
		−20.0	117.4	−20.0	485			
		−10.0	127.4	+12.0		48		
		+5.5	142.9	+9.5	121			
		+30.0	167.4	+19.5		73		
		+40.0	177.4	+27.0		97		
		+41.5	178.9	+19.0	73			
		+51.0	188.4	−16.0		1,115		
		+59.5	196.9	+21.5		1,018	3,818	
May 25	11 9	−50.0	74.2	+6.0		48		Do.
		−21.5	102.7	+12.5		776		
		−7.5	116.7	−20.0	485			
		+19.0	143.2	+10.0	97			
		+45.0	169.2	+19.0		48		
		+51.0	175.2	+27.0		97		
		+56.0	180.2	+18.5	97			
		+59.0	183.2	+29.0	24			

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Heliographic			Area		Total area for each day	Observatory
		Diff. in longitude	Longitude	Latitude	Spot	Group		
1937	h m	°	°	°				
May 25	11 9	+65.0	189.2	−17.0		1,115		U. S. Naval.
		+73.0	197.2	+21.0		970	3,757	
May 26	12 0	−37.0	73.5	+5.0		48		Do.
		−8.0	102.5	+12.0		679		
		+8.0	118.5	−20.0	485			
		+32.0	142.5	+9.5	73			
		+66.0	176.5	+27.0		97		
		+69.0	179.5	+18.5	73			
		+70.0	180.5	−16.0	97			
		+83.0	193.5	−14.0		194	1,746	
May 27	10 53	−25.0	72.9	+5.0		97		Do.
		+6.0	103.9	+12.0		679		
		+15.5	113.4	−16.0		24		
		+20.0	117.9	−20.0	485			
		+45.0	142.9	+9.5	48		1333	
May 28	11 0	−11.0	73.6	+5.0		73		Do.
		+19.0	103.6	+12.0		679		
		+33.0	117.6	−20.0	436			
		+37.0	121.6	+13.0		48		
		+59.0	143.6	+9.0	48		1284	
May 29	11 1	−85.0	346.3	+11.0		388		Do.
		+3.0	74.3	+5.0		73		
		+32.0	103.3	+12.0		679		
		+47.0	118.3	−20.0	436			
		+51.0	122.3	+12.5		97		
		+70.0	141.3	+9.0	24		1697	
May 30	8 41	−73.0	346.4	+12.0		679		Mt. Wilson.
		−4.0	55.4	+16.0		145		
		+13.0	72.4	+5.0	48			
		+44.0	103.4	+11.0		727		
		+61.0	120.4	−21.0	436			
		+65.0	124.4	+11.5		194	2229	
May 31	8 42	−57.0	349.1	+12.0		582		Do.
		+11.0	57.1	+16.0		242		
		+60.0	106.1	+10.5		824		
		+71.0	117.1	+11.0	97			
		+71.0	117.1	−22.0	436		2181	

Mean daily area for 31 days, May, 2080.

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR MAY 1937

[Dependent alone on observations at Zurich and its station at Arosa]

[Furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich, Switzerland]

May 1937	Relative numbers	May 1937	Relative numbers	May 1937	Relative numbers
1	89	11	*a* 99	21	*aad* 154
2	91	12	91	22	*Eac* 194
3	77	13	—	23	202
4	*ad* 56	14	*Ecd* 111	24	*a* 213
5	59	15	*ad* 140	25	171
6	46	16	*Wc* 183	26	*a* 130
7	47	17	184	27	*b* 93
8	*Ec* 50	18	*d* 158	28	71
9	*d* 68	19	158	29	*Ecd* 83
10	*Mac* 103	20	*bd* 177	30	103
				31	98

Mean, 30 days = 116.9.

a = Passage of an average sized group through the central meridian.
b = Passage of a large group or spot through the central meridian.
c = New formation of a group developing into a middle sized or large center of activity; *E*, on the eastern part of the sun's disc; *W*, on the western part; *M*, in the central circle zone.
d = Entrance of a large or average sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. Little, in charge]

By Loyd A. Stevens

Mean free-air data, based on airplane weather observations during the month of May 1937, are given in tables 1 to 3.

The mean surface temperatures for May (see ch. I) were, in general, above normal over the entire country; the departures from normal being small except over the central and northern portions of the Rocky Mountain and Western Plateau regions and along the New England coast, where, for individual stations, they amounted to between 2° and 3° C.

The mean free-air temperatures for the month up to 5 km above sea level (table 1) were slightly above normal over the greater portion of the country; negative departures being confined, for the most part, to the extreme northwest and the southeast portions of the country. The eastern area of negative departures was small at

0.5 km, being evident in the records of only Norfolk and Murfreesboro, but increased with height until at 4 km it covered approximately the entire region east of a line between Lakehurst, N. J., and San Antonio, Tex. The greatest negative departure (−2.4° C.) occurred at Norfolk, Va. at 2 km and the greatest positive departure (+2.3° C.) occurred at Billings, Mont. at 5 km.

The mean free-air relative humidities, as shown in table 2, were in general near normal. The greatest negative departure (−8 percent) occurred at Pensacola, Fla. at 0.5 km and the greatest positive departure (+8 percent) occurred at Oklahoma City, Okla. at 5 km. At San Antonio, Tex. the relative humidity was generally below normal at all upper levels. At Fargo, N. Dak., Scott Field, Ill., and Mitchell Field, N. Y., on the other hand, it was above normal at all levels. Over the southeast portion of the country it was below normal up to 1.5 km, above normal at intermediate levels and below normal again at 5 km. At Omaha and Oklahoma City the trend was similar to that over the southeast portion of the country except that positive departures persisted up to the 5 km level.

Monthly mean free-air barometric pressures and equivalent potential temperatures are shown in table 3. The mean isobaric charts for 0.5 and 1 km, as drawn from these values, were characterized by high pressure over the southeast and northwest sections of the country (the higher pressure prevailing over the former region) and by a trough of low pressure extending in a NE.–SW. direction from the northern plains States to the southern California coast. In the higher levels, one statistical center of low pressure was located over Fargo and Sault Ste. Marie and another over Seattle, Wash., while the highest mean pressure prevailed over the west Gulf coast. An examination of the mean pressure gradients between selected pairs of stations indicated that, in general, there was a decrease in pressure gradient varying from 20 to 50 percent over most of the country from April to May. From San Antonio to Oakland, on the other hand, the mean pressure gradient was reversed at 0.5 km and showed a marked increase over April up to 2.5 km. It agreed closely, however, with the gradient for the month of March.

Free-air resultant winds based on pilot balloon observations made near 5 a. m. (75th meridian time), are shown in table 4. The resultant winds, with a few exceptions were close to the normal in both direction and velocity at most stations at all levels. The most notable exceptions follow: At San Diego the resultant directions varied from the normal in a clockwise direction by amounts of from 35° to 80° between 0.5 km and 2 km. At Pensacola at 0.5 km the current months' resultant was 300° (WNW.) and 2.0 m. p. s. while the normal was 117° (ESE.) and 0.8 m. p. s., also at 4 km the current resultant direction varied from the normal in a clockwise direction by approximately 80° and the velocity was less than 50 percent of the normal. At Seattle the current month's resultant directions varied from the normal in a counterclockwise direction and the velocities were above normal at all levels up to 3 km; the greatest variation occurring at 2 km where the current resultant was 145° (SE) and 3.1 m. p. s. while the normal for this level was 243° (WSW). and 1.8 m. p. s. At Sault Ste. Marie the current month's resultant directions were 233° (SW.) and 182° (S.) at 2 and 2.5 km, respectively, while the corresponding normal directions were 297° (WNW.) and 303° (NW.). The current resultant velocities at Sault Ste. Marie were only 21 percent of normal at 2 km and 28 percent of normal at 2.5 km. At 4 km, furthermore, the current resultant velocity was only 1.7 m. p. s. as compared with a normal of 8.9 m. p. s. At Key West the current month's resultant directions varied from the normal in a counterclockwise direction at all levels up to 3 km where the direction was 81° (E.) and the normal 202° (SSW.).

Table 5 shows the maximum free-air wind velocities and their directions for various sections of the United States during May, as determined by pilot-balloon observations. The extreme maximum was 51.2 m. p. s. from the WSW. at 4,280 meters above sea level over Medford, Oreg.

The mean monthly equivalent potential temperatures and specific humidities are shown in tables 2 and 3, respectively. The increase in equivalent potential temperature of May over April amounted to about 10° A. on the average, the greatest change (+17° A.) occurred at Omaha at 0.5 km and the smallest (+2° A.) occurred at San Diego at 5 km. The average increase in specific humidity of May over April varied from 2 to 3 grams in the lower levels to 0.2 to 1.3 grams at 5 km. In general, the locations of centers of highest and lowest specific humidity and equivalent potential temperature agreed closely with those of highest and lowest pressure.

The weather of the month was characterized by frequent influxes of rather large areas of polar air which moved, for the most part, across the northern part of the country. During the early part of the month several cyclonic areas developed over the southern States and moved slowly north or northeast. In two cases these areas moved slightly northwestward and became temporarily stagnated over the central part of the country, when their eastward movement was blocked by large polar air masses.

During the latter half of the month several cyclones entered the country from the northwest or developed over the northern plains States and moved eastward across the country usually with troughs of low pressure extending to the southwest formed by inflowing tropical air from the region of the west Gulf States. In general both the horizontal and vertical temperature gradients along the fronts between the tropical and polar air currents, associated with the low pressure centers and troughs, were unusually steep and gave rise to an unusually large number of thunderstorms. The frequency of thunderstorms accounts for the very uneven amounts of percipitation which resulted, precipitation being below normal in 33 of the 48 States and above normal in the remainder. The deficiency of precipitation in California (24 percent of normal) appears to have resulted from an almost complete lack of frontal activity in that region and a lack of inflowing air from the Pacific. During the greater part of the month a more or less stationary low pressure center persisted over southern Nevada and Arizona. The circulation about this center resulted in dry N. or NE. winds blowing over the State from the mountains instead of NW. winds from the ocean which normally prevail during this month.

TABLE 1.—*Mean free-air temperatures (t), °C. obtained by airplanes during May 1937. (Dep. represents departure from "normal" temperature)*

Station	Altitude (meters) m. s. l.																			
	Surface			500		1,000		1,500		2,000		2,500		3,000		4,000		5,000		
	Number of obs.	t	Dep.	t	Dep.	t	Dep.	t	Dep.	t	Dep.	t	Dep.	t	Dep.	t	Dep.	t	Dep.	
Barksdale Field (Shreveport), La.[1] (52 m)	31	19.8	.....	20.0	.....	17.8	.....	15.1	.....	11.8	.....	8.9	.....	6.1	.....	0.5	.....	.....	.....	
Billings, Mont.[2] (1,089 m)	31	10.8	+0.8	.....	.....	.....	.....	12.8	+1.0	10.2	+1.0	6.7	+1.1	3.0	+1.1	−3.5	+1.5	−9.5	+2.3	
Boston, Mass.[1] (5 m)	24	11.8	−0.7	13.2	+1.6	11.1	+1.8	8.3	+1.8	5.3	+1.3	2.7	+1.0	−0.2	+0.7	−5.3	+0.7	.....	.....	
Cheyenne, Wyo.[2] (1,873 m)	31	7.0	+0.4	.....	.....	.....	.....	.....	.....	8.4	+1.0	7.0	+1.0	4.1	+1.1	−3.3	+0.8	−10.8	+0.7	
Coco Solo, C. Z.[3] (15 m)	23	25.8	.....	23.9	.....	21.3	.....	18.5	.....	15.8	.....	13.4	.....	10.9	.....	5.2	.....	−0.8	.....	
El Paso, Tex.[2] (1,194 m)	31	17.7	.....	.....	.....	.....	.....	20.3	.....	17.4	.....	13.9	.....	10.3	.....	2.2	.....	−5.7	.....	
Fargo, N. Dak.[2] (274 m)	30	9.8	+1.0	12.5	+0.6	10.6	+0.3	8.2	+0.5	5.8	+0.8	2.9	+0.8	0.0	+0.7	−5.8	+0.4	−12.4	+0.2	
Kelly Field (San Antonio), Tex.[1] (206 m)	31	19.4	+0.1	19.9	+0.2	18.4	−0.1	16.8	−0.1	14.3	−0.2	11.7	−0.2	8.8	−0.3	2.3	−0.2	−4.6	−0.2	
Lakehurst, N. J.[3] (39 m)	25	10.7	+0.1	14.4	+1.8	12.1	+1.5	8.7	+0.7	5.5	+0.1	2.8	−0.1	0.6	−0.2	−4.7	−0.6	−10.8	−1.0	
Maxwell Field (Montgomery), Ala.[1] (52 m)	26	20.7	+0.7	21.4	+0.2	18.3	0.0	14.6	−0.1	11.3	−0.5	8.1	−0.7	5.1	−0.8	0.0	−0.3	−5.7	−0.2	
Miami, Fla.[3] (4 m)	31	19.6	.....	21.2	.....	18.0	.....	15.0	.....	12.3	.....	10.2	.....	7.4	.....	1.9	.....	−3.5	.....	
Mitchel Field (Hempstead, L. I.), N. Y.[1] (29 m)	27	11.8	+0.4	14.1	+0.7	12.4	+0.9	9.2	+0.4	6.1	0.0	3.2	−0.2	1.0	−0.2	−4.8	−0.5	.....	.....	
Murfreesboro, Tenn.[2] (174 m)	31	15.3	+0.1	17.4	−0.3	15.1	−0.8	12.5	−0.6	9.5	−0.8	6.7	−1.0	4.7	−0.5	−2.1	−0.9	−8.2	−0.9	
Norfolk, Va.[3] (10 m)	24	15.6	−1.9	16.6	−0.8	13.7	−1.6	10.2	−2.3	7.1	−2.4	5.2	−1.6	2.8	−1.4	−3.0	−1.6	−9.1	−1.6	
Oakland, Calif.[3] (2 m)	31	11.1	.....	13.6	.....	15.2	.....	13.8	.....	11.5	.....	8.8	.....	5.8	.....	−0.7	.....	−7.0	.....	
Oklahoma City, Okla.[3] (391 m)	31	17.1	+0.2	18.4	+0.9	19.1	+1.8	16.6	+1.5	13.9	+1.4	10.8	+1.3	7.4	+1.3	0.0	+1.1	−7.4	+1.0	
Omaha, Nebr.[2] (300 m)	31	14.0	+0.4	15.5	+0.8	14.8	+0.5	12.9	+0.8	9.8	+0.2	6.3	−0.3	3.3	−0.2	−3.1	+0.1	−9.8	+0.4	
Pearl Harbor, T. H.[3] (6 m)	31	21.3	−3.6	19.8	−1.4	16.8	−0.6	14.1	−0.5	11.9	−0.6	10.8	−0.6	8.7	−0.9	3.4	−1.2	−1.9	−0.1	
Pensacola, Fla.[3] (13 m)	29	20.4	−1.7	21.2	+0.4	17.9	−0.2	14.6	−0.6	11.4	−1.2	8.3	−1.7	5.5	−1.9	0.9	−0.7	−4.3	+0.2	
St. Thomas, Virgin Island[3] (8 m)	30	27.0	.....	23.4	.....	19.9	.....	17.3	.....	15.0	.....	12.4	.....	10.0	.....	4.6	.....	−0.6	.....	
Salt Lake City, Utah[2] (1,288 m)	31	11.5	.....	.....	.....	.....	.....	15.7	.....	13.1	.....	9.7	.....	6.0	.....	−1.0	.....	−7.8	.....	
San Diego, Calif.[3] (10 m)	22	16.0	−1.5	13.8	−0.4	14.4	+0.3	15.5	+2.2	13.6	+1.6	10.8	+1.5	8.0	+1.5	1.7	+1.2	−5.6	+0.6	
Sault Ste. Marie, Mich.[2] (221 m)	31	6.6	.....	9.9	.....	8.6	.....	6.2	.....	3.5	.....	0.9	.....	−1.6	.....	−7.2	.....	−13.5	.....	
Scott Field (Belleville), Ill.[1] (135 m)	28	13.8	+0.6	17.0	+0.2	14.9	0.0	12.6	+0.6	9.9	+0.6	6.9	+0.1	4.1	+0.1	−2.5	−0.3	−9.1	−0.5	
Seattle, Wash.[3] (10 m)	21	9.6	−2.6	8.5	−1.5	6.4	−1.2	3.6	−1.2	1.5	−0.5	−0.7	−0.3	−2.5	+0.2	−8.5	0.0	−15.3	−0.4	
Selfridge Field (Mount Clemens), Mich.[1] (177 m)	31	10.0	+0.4	13.0	+0.6	10.8	+0.5	8.0	+0.6	5.3	+0.5	2.4	+0.2	−0.2	0.0	−6.1	−0.2	−11.9	+0.5	
Spokane, Wash.[3] (596 m)	31	9.2	−2.0	.....	.....	12.9	+0.2	10.7	−0.2	7.0	−0.7	3.3	−0.9	−0.1	−0.8	−6.2	−0.4	−12.9	+0.1	
Washington, D. C.[3] (13 m)	30	13.8	−2.1	15.5	+0.4	13.0	−0.2	9.9	−0.7	6.7	−1.4	4.1	−1.3	1.8	−1.1	−3.5	−1.1	−9.6	−1.2	
Wright Field (Dayton), Ohio[1] (244 m)	29	11.7	+0.4	14.1	0.0	13.4	+0.2	10.3	−0.1	8.0	+0.2	5.7	+0.4	3.2	+0.5	−2.3	+0.5	−8.6	+0.5	

[1] Army.
[2] Weather Bureau.
[3] Navy.

Observations taken about 4 a. m., 75th meridian time except by Navy stations along the Pacific coast and Hawaii where they are taken at dawn.

NOTE.—The departures are based on normals covering the following total number of observations made during the same month in previous years, including the current month (years of record are given in parentheses following the number of observations): Billings, 93 (3); Boston, 127 (5); Cheyenne, 89 (3); Fargo, 92 (3); Kelly Field 85 (3); Lakehurst, 78 (3); Maxwell Field, 85 (3); Mitchel Field, 83 (3); Murfreesboro, 92 (3); Norfolk, 161 (8); Oklahoma City, 90 (3); Omaha, 186 (6); Pearl Harbor, 162 (7); Pensacola, 225 (10); San Diego, 196 (9); Scott Field, 80 (3); Seattle, 64 (3), Selfridge Field, 89 (3); Spokane, 93 (3); Washington, 224 (10); Wright Field, 88 (3).

TABLE 2.—*Mean free-air relative humidities (R. H.), in percent, and specific humidities (q), in grams/kilogram, obtained by airplanes during May 1937. (Dep. represents departure from "normal" relative humidity)*

Station	Altitude (meters) m. s. l.																						
	Surface				500			1,000			1,500			2,000			2,500			3,000			4,000			5,000		
	Number of observations	q	R. H.		q	R. H.		q	R. H.		q	R. H.		q	R. H.		q	R. H.		q	R. H.		q	R. H.		q	R. H.	
			Mean	Dep.		Mean	Dep.		Mean	Dep.		Mean	Dep.		Mean	Dep.		Mean	Dep.		Mean	Dep.		Mean	Dep.		Mean	Dep.
Barksdale Field, La.	30	11.3	79	.....	10.0	65	.....	8.6	60	.....	7.0	55	.....	5.8	53	.....	4.9	51	.....	4.0	47	.....	3.2	49	.....	.....	.....	.....
Billings, Mont.	31	5.2	57	−7	.....	.....	.....	5.2	48	−3	4.8	49	−2	4.2	52	−2	3.9	58	0	2.8	60	+1	1.7	49	−4	.....	.....	.....
Boston, Mass.	24	6.5	76	+7	5.9	60	−1	5.2	57	−2	4.9	61	+1	4.1	59	0	3.6	59	+3	3.0	57	+3	2.2	51	+2	.....	.....	.....
Cheyenne, Wyo.	31	5.7	74	−2	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.9	68	−3	5.3	63	0	4.3	60	+1	3.0	60	+1	1.9	62	+2
Coco Solo, Canal Zone	23	19.1	92	.....	17.0	87	.....	14.8	84	.....	13.5	85	.....	11.5	82	.....	9.5	75	.....	7.7	67	.....	5.1	59	.....	4.0	63	.....
El Paso, Tex.	31	5.7	40	.....	.....	.....	.....	.....	.....	.....	6.5	37	.....	5.4	35	.....	4.6	35	.....	3.6	33	.....	2.8	39	.....	2.1	46	.....
Fargo, N. Dak.	30	6.0	78	0	6.2	66	+2	5.9	67	+6	5.3	65	+6	4.3	61	+3	3.6	58	+2	3.2	56	+3	2.1	51	+2	1.3	50	+4
Kelly Field, Tex.	31	12.2	85	−6	12.5	82	−2	10.0	68	−6	8.0	57	−5	6.8	54	−3	5.4	48	−6	4.4	45	−4	3.2	45	−2	2.1	44	0
Lakehurst, N. J.	25	7.4	92	+6	6.7	63	0	5.7	59	0	5.1	61	0	4.3	59	0	3.6	58	0	2.8	48	−2	1.8	42	−3	1.0	33	−5
Maxwell Field, Ala.	26	12.0	78	−3	9.6	57	−5	8.2	55	−7	7.6	60	−4	6.3	58	+1	5.3	58	+3	4.2	53	+2	2.7	42	0	1.5	32	−1
Miami, Fla.	31	13.0	91	.....	13.4	81	.....	10.7	75	.....	8.6	68	.....	6.8	61	.....	5.3	51	.....	4.6	50	.....	3.0	43	.....	2.1	38	.....
Mitchel Field, N. Y.	27	7.2	84	+2	7.4	71	+2	6.9	69	+2	6.2	72	+4	5.4	74	+4	4.5	69	+5	3.8	61	+2	2.3	55	+1	.....	.....	.....
Murfreesboro, Tenn.	31	9.8	89	+3	8.2	63	−4	7.5	63	−2	6.8	64	−3	6.2	67	+2	5.1	62	+3	4.9	64	+7	2.6	51	+2	1.6	41	−2
Norfolk, Va.	24	9.0	82	+8	7.4	59	−3	6.4	58	0	5.3	59	+1	4.7	58	+1	3.6	50	−5	3.0	45	−7	1.8	38	−6	1.1	35	−6
Oakland, Calif.	30	6.9	85	.....	7.2	70	.....	5.9	49	.....	4.3	37	.....	3.5	33	.....	2.9	31	.....	2.4	30	.....	1.6	28	.....	1.1	27	.....
Oklahoma City, Okla.	31	10.0	79	−4	10.0	72	−4	9.5	62	−1	8.5	61	+1	7.2	58	+2	6.0	56	+3	4.8	52	+3	3.1	51	+2	2.3	57	+8
Omaha, Nebr.	31	8.4	82	+3	8.3	72	0	7.2	62	−2	6.5	59	−2	5.5	58	0	4.8	61	+3	4.1	60	+5	2.8	58	+6	1.8	54	+4
Pearl Harbor, T. H.	31	12.7	81	+12	12.3	81	+6	11.4	85	+4	9.6	81	+4	7.5	69	+3	5.4	51	+2	4.1	42	+5	2.6	34	+7	1.9	32	+7
Pensacola, Fla.	29	13.5	91	+8	11.1	67	−8	9.1	64	−6	8.0	66	0	6.6	63	+4	5.3	58	+5	4.1	53	+5	2.5	38	−1	1.3	28	−5
St. Thomas, Virgin Island	30	17.5	79	.....	16.2	86	.....	14.2	88	.....	11.9	81	.....	9.1	71	.....	7.4	62	.....	5.7	53	.....	4.6	56	.....	3.2	49	.....
Salt Lake City, Utah	31	5.7	58	.....	.....	.....	.....	.....	.....	.....	6.5	49	.....	5.6	47	.....	4.8	48	.....	4.2	51	.....	3.2	56	.....	2.4	61	.....
San Diego, Calif.	22	8.9	78	+6	8.0	77	0	7.6	66	+3	6.3	48	−1	4.9	40	+2	3.8	36	+3	3.0	32	+3	1.9	28	+2	1.2	27	+3
Sault Ste. Marie, Mich.	31	4.8	78	.....	5.4	67	.....	5.0	64	.....	4.4	62	.....	3.9	63	.....	3.4	61	.....	2.8	58	.....	1.8	50	.....	1.0	42	.....
Scott Field, Ill.	28	8.7	88	+2	7.9	62	+1	7.3	62	+3	6.4	60	+1	5.6	60	+1	4.7	56	+4	3.7	51	+2	2.6	52	+5	1.7	49	+6
Seattle, Wash.	21	6.2	85	+9	5.8	79	+4	4.9	74	+3	4.2	72	+3	3.7	67	0	3.0	62	0	2.6	58	0	1.7	53	+1	1.0	49	+1
Selfridge Field, Mich.	31	6.4	83	+1	6.5	66	+4	5.8	64	+4	4.8	60	+1	3.9	56	−1	3.2	53	0	2.6	48	0	1.7	44	+2	1.2	46	+6
Spokane, Wash.	31	5.2	68	+5	.....	.....	.....	5.3	52	−2	4.6	48	−4	4.0	50	−2	3.5	54	−1	2.8	55	−3	2.0	51	−4	1.2	48	−1
Washington, D. C.	30	8.1	83	+12	6.5	57	−3	6.0	58	+2	5.3	60	+4	4.8	63	+7	4.0	59	+6	3.1	51	0	1.9	41	0	1.1	35	−1
Wright Field, Ohio	29	7.5	86	+1	7.4	70	+3	7.0	65	+4	6.0	66	+3	5.0	60	0	3.9	51	−3	3.3	48	−5	2.2	43	−7	1.4	42	−5

TABLE 3.—*Mean free-air barometric pressures (P), in mb, and equivalent potential temperatures (θ_a), in °A. obtained by airplanes during May 1937*

Station	Altitude (meters) m. s. l.																	
	Surface			500		1,000		1,500		2,000		2,500		3,000		4,000		5,000	
	Number of observations	P	θ_a	P	θ_a	P	θ_a	P	θ_a	P	θ_a	P	θ_a	P	θ_a	P	θ_a	P	θ_a
Barksdale Field, La.	*31	1,009	323	957	325	903	324	851	323	802	321	754	320	710	321	628	323		
Billings, Mont.	31	891	308					849	315	800	317	752	316	708	317	624	318	550	318
Boston, Mass.	24	1,015	302	957	306	902	307	849	309	799	309	751	310	706	311	622	314		
Cheyenne, Wyo.	31	812	314							800	318	752	320	708	320	624	319	550	318
Coco Solo, Canal Zone	23	1,009	352	952	350	900	346	849	345	800	342	754	340	710	337	629	335	557	335
El Paso, Tex.	31	879	319					848	327	800	327	754	326	710	324	629	324	555	324
Fargo, N. Dak.	30	981	301	955	307	900	309	847	310	797	310	750	310	704	312	620	314	546	315
Kelly Field, Tex.	31	992	328	960	332	906	328	855	327	806	326	759	325	715	324	634	324	560	324
Lakehurst, N. J.	25	1,011	303	958	310	903	310	850	310	800	310	753	310	708	311	624	313	550	315
Maxwell Field, Ala.	26	1,010	326	959	326	906	324	854	323	805	321	757	320	713	319	630	320	556	321
Miami, Fla.	31	1,014	327	958	336	905	350	853	327	805	324	757	323	714	323	631	324	557	326
Mitchel Field, N. Y.	27	1,012	303	958	312	902	314	850	314	799	314	752	314	706	314	622	315		
Murfreesboro, Tenn.	31	995	316	960	317	904	319	852	319	802	320	755	319	710	321	628	318	554	319
Norfolk, Va.	24	1,015	312	958	314	903	314	851	312	801	312	753	312	708	314	625	315	551	317
Oakland, Calif.	*31	1,015	302	956	310	902	314	850	313	801	314	754	315	710	316	627	317	553	318
Oklahoma City, Okla.	31	968	321	955	324	902	329	850	328	802	327	755	326	711	324	629	322	555	322
Omaha, Nebr.	31	978	312	956	316	902	317	850	319	801	318	754	318	709	318	626	318	551	318
Pearl Harbor, T. H.	31	1,016	328	960	331	906	331	854	329	805	325	758	324	714	323	632	324	558	327
Pensacola, Fla.	29	1,016	330	961	329	907	326	854	325	805	323	757	321	712	320	630	321	556	323
St. Thomas, Virgin Islands	30	1,016	348	961	346	907	342	855	339	807	334	759	331	715	329	634	331	560	332
Salt Lake City, Utah	31	869	313					847	322	798	322	751	322	708	322	625	322	552	323
San Diego, Calif.	22	1,013	312	956	313	900	318	848	322	800	320	753	320	709	320	627	321	553	321
Sault Ste. Marie, Mich.	31	989	294	957	301	901	304	847	306	797	307	749	308	704	309	620	311	546	312
Scott Field, Ill.	28	1,000	311	959	316	905	318	853	318	804	318	756	318	711	317	628	318	554	318
Seattle, Wash.	21	1,018	298	960	301	902	302	848	302	798	304	749	305	704	307	620	309	545	310
Selfridge, Mich.	31	994	301	957	308	902	309	850	308	800	308	752	309	706	310	622	311	548	315
Spokane, Wash.	31	945	302			901	310	849	311	799	311	751	311	706	310	622	312	549	313
Washington, D. C.	30	1,017	308	959	311	903	312	851	312	801	313	753	313	708	313	624	315	550	317
Wright Field, Ohio	29	987	307	956	312	901	315	849	315	800	315	752	314	708	315	625	317	551	319

* θ_a 30 observations.

TABLE 4.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 5 a. m. (E. S. T.) during May 1937*

[Wind from N.=360°, E.=90°, etc.]

Altitude (meters) m. s. l.	Albuquerque, N. Mex. (1,554 m)		Atlanta, Ga. (309 m)		Billings, Mont. (1,088 m)		Boston, Mass. (15 m)		Cheyenne, Wyo. (1,873 m)		Chicago, Ill. (192m)		Cincinnati, Ohio (153 m)		Detroit, Mich. (204 m)		Fargo, N. Dak. (274 m)		Houston, Tex. (21 m)		Key West, Fla. (11 m)		Medford, Oreg. (410 m)		Murfreesboro, Tenn. (180 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	85	1.3	4	0.2	333	2.3	285	1.3	270	2.5	234	0.1	87	0.4	249	0.9	111	1.8	89	0.8	68	1.8	276	0.6	188	0.4
500			270	0.02			311	6.0			207	1.2	173	2.5	246	2.6	148	3.0	178	5.1	87	3.6	283	1.2	190	1.5
1,000			260	2.0			312	5.1			284	2.7	244	3.4	263	4.0	236	2.6	183	4.6	73	3.1	315	1.8	249	3.6
1,500			259	3.7	334	1.7	311	4.3			276	3.6	271	6.2	282	4.3	255	1.9	181	3.8	83	1.6	160	0.5	264	5.6
2,000	160	1.0	277	5.2	302	1.6	296	5.0	278	3.2	289	3.2	296	5.3	280	6.2	269	3.8	185	2.6	63	1.3	179	1.8	273	6.3
2,500	255	3.2	279	4.8	283	2.7	294	5.7	292	4.8	293	5.8	323	2.8	281	6.6	311	5.3	223	2.4	77	1.5	221	3.2	282	7.2
3,000	281	3.8	294	4.7	266	3.8	269	7.4	292	5.6	298	8.0			277	6.3	312	5.7	273	2.0	81	1.2	242	5.2	293	6.5
4,000	267	6.5			253	4.9	281	6.8	284	6.9	299	7.7			299	8.6	315	9.9	332	3.1			285	5.4		
5,000	242	7.5			192	3.6			280	6.9					321	8.1										

Altitude (meters) m. s. l.	Newark, N. J. (14 m)		Oakland, Calif. (8 m)		Oklahoma City, Okla. (402 m)		Omaha, Nebr. (306 m)		Pearl Harbor, Territory of Hawaii [1] (68 m)		Pensacola, Fla.[1] (24 m)		St. Louis, Mo. (170 m)		Salt Lake City, Utah (1,294 m)		San Diego, Calif. (15 m)		Sault Ste. Marie, Mich. (198 m)		Seattle, Wash. (14 m)		Spokane, Wash. (603 m)		Washington, D. C. (10 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	249	1.6	216	1.0	184	2.9	154	0.7	47	3.4	334	1.7	190	0.5	139	2.6	326	0.3	3	0.5	153	1.2	147	1.0	284	0.5
500	281	6.7	302	3.3	173	3.8	202	1.7	72	6.3	300	2.0	201	2.6			331	0.7	10	1.2	161	1.0			269	5.2
1,000	285	6.4	343	5.4	209	7.6	240	4.4	85	5.5	229	1.4	253	3.6			356	2.5	313	2.0	159	1.9	186	1.3	283	5.4
1,500	287	7.2	339	2.7	231	6.0	246	5.5	101	4.0	221	1.8	279	4.3	138	2.2	12	4.8	349	2.4	143	2.5	227	2.0	271	4.7
2,000	293	6.7	310	1.7	243	5.6	260	5.0	99	3.1	206	1.7	275	5.0	207	1.0	33	4.2	233	1.2	145	3.1	229	2.6	269	6.6
2,500	303	6.0	309	3.1	264	5.3	285	4.8	98	1.8	230	1.7	281	5.1	246	2.4			182	1.8	166	4.6	248	3.5	278	7.7
3,000	303	7.3	251	3.3	272	5.2	298	6.0	64	2.4	305	1.8	296	7.4	270	3.2			337	2.5	207	3.8	250	5.3	269	8.1
4,000	316	9.5	267	4.6	324	5.0	275	5.5	29	2.9	7	1.6	208	7.6	258	5.9			353	1.7			241	6.6	278	6.7
5,000															269	8.3									284	8.6

[1] Navy stations.

TABLE 5.—*Maximum free-air wind velocities (M. P. S.), for different sections of the United States based on pilot-balloon observations during May 1937*

Section	Surface to 2,500 meters (m. s. l.)					Between 2,500 and 5,000 meters (m. s. l.)					Above 5,000 meters (m. s. l.)				
	Maximum velocity	Direction	Altitude (m) M. S. L.	Date	Station	Maximum velocity	Direction	Altitude (m) M. S. L.	Date	Station	Maximum velocity	Direction	Altitude (m) M. S. L.	Date	Station
Northeast [1]	31.5	SW	1,046	13	Cleveland	37.0	WNW	4,410	17	Columbus	44.8	WNW	6,095	18	Cleveland.
East-Central [2]	26.2	W	1,860	16	Cincinnati	31.6	W	3,160	17	Washington	44.0	W	11,520	1	Greensboro.
Southeast [3]	25.5	E	660	1	Tampa	24.5	WSW	2,680	5	Spartanburg	34.1	W	11,280	4	Charleston.
North-Central [4]	30.2	NW	1,382	12	Bismark	30.8	NW	3,890	19	Detroit	40.0	NW	10,570	14	St. Paul.
Central [5]	30.2	SSW	2,460	11	Davenport	29.0	NW	4,240	17	Chicago	33.5	NNW	7,300	14	Wichita.
South-Central [6]	28.8	S	1,010	19	Oklahoma City	33.6	SW	3,550	20	Amarillo	41.2	SW	12,690	31	Abilene.
Northwest [7]	25.8	SE	2,440	2	Seattle	51.2	WSW	4,280	28	Medford	39.9	WSW	9,294	14	Portland.
West-Central [8]	35.7	SSW	2,470	18	Modena	39.6	SW	3,735	14	Modena	39.6	W	7,610	15	Rock Springs.
Southwest [9]	33.4	WSW	1,902	15	Winslow	40.0	SSW	4,638	25	Winslow	36.5	S.	6,684	28	Albuquerque.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, Southern Ohio, Kentucky, Eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

RIVERS AND FLOODS

[River and Flood Division, MERRILL BERNARD in charge]

By BENNETT SWENSON

The following report of flood losses for the Ohio River and tributaries at and above Wheeling, W. Va., during the flood of April 26, was received too late for inclusion in the April REVIEW and is presented herewith: Allegheny River, $352,000; Monongahela River, $788,000; and the Ohio River at and above Wheeling, W. Va., $533,300. Reported savings as a result of flood warnings for this section amounted to about $1,500,000.

Atlantic Slope and East Gulf Drainage.—Most of the streams in this area from North Carolina southward reached flood stage late in April or the first part of May as a result of rains during the latter part of April. Additional rains occurred during the first week of May, particularly over portions of the East Gulf States, and increased the stages considerably in the Tombigbee River. No losses of consequence occurred as a result of these floods, except as follows: Altamaha River, $33,750; Apalachicola River, $5,500; and Tombigbee River, $171,000.

Frequent rains in the New England States during most of the month, with unusually heavy rains occurring on the 14th and 15th, resulted in a moderate flood in the Connecticut River. Reports of losses have not been received.

Upper Mississippi Valley.—The flood in the Illinois River began about April 21 and continued through the third week in May. The flood was light, and the only loss of consequence was to prospective crops, with a total loss amounting to $25,000.

A small flood occurred in the Meramec River during the first week of May, but no losses of consequence were reported.

Missouri Valley.—Heavy rains over the upper and middle Floyd and Big Sioux River watersheds on the night of May 25–26 resulted in flooding in these basins. The losses in the Floyd River amounted to about $44,000 and in the Big Sioux River, $15,000.

The following item of interest, concerning the low stage in the Missouri River at Sioux City, Iowa, during May has been furnished by the official in charge at that station:

From May 14 to 26, inclusive, the Missouri River was at the lowest stage of record for the month of May at the Sioux City station. 4.6 feet on May 26, 1931, was the previous low stage. On May 24, 1937, the gage reading was 3.6 feet, or 1.0 foot under the previous low reading for May. The record begins with 1879, and it is continuous for a period of 59 years.

The average stage for May 1937 at Sioux City was 4.6 feet, or 3.7 feet below the 59-year average. This was one-half foot lower than the average stage in 1889 and 1931, the previous low.

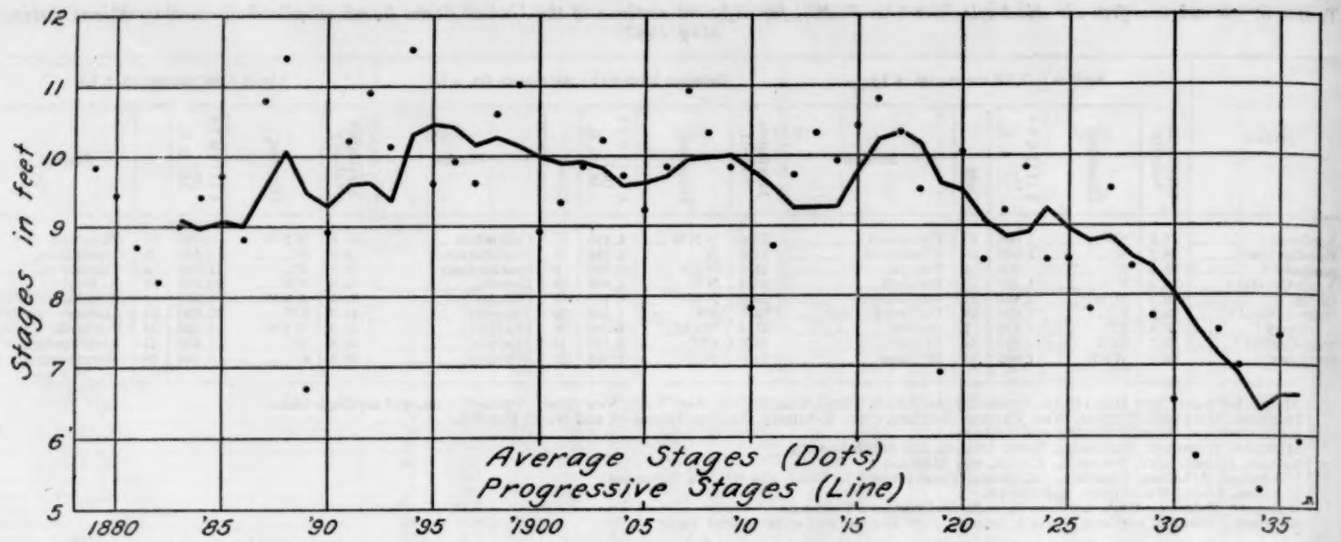
The accompanying graph, also prepared at Sioux City, Iowa, shows the marked decline of the summer stages in the Missouri River at Sioux City during the last 17 years. These changing conditions are well illustrated by the low level of the water table in recent years in the middle Missouri Valley.

Ohio and lower Mississippi Valleys.—Heavy rains during the first four days of May caused moderate floods in the lower White and the middle and lower Wabash Rivers. The damage was mostly to prospective crops and amounted to about $14,000.

Light floods occurred in the lower Cumberland and in the Green River in Kentucky, but no losses of consequence were incurred.

The crest of the April flood in the upper Ohio River flattened out as it progressed downstream and did not exceed flood stage after passing Point Pleasant, W. Va. However, a weak low-pressure area appeared over the lower Mississippi Valley on the first of May and moved slowly northward to southeastern Missouri, where it remained almost stationary until the 5th before it finally moved eastward. This condition caused frequent and widespread rains over the central Mississippi and lower Ohio River Basins. These rains augmented the rise in the Ohio River so that shortly before the rise reached Evansville, Ind., flood stage was again exceeded and the flooding continued downstream to the mouth of the Ohio and on the lower Mississippi to Helena, Ark. Moderate flooding also occurred in the White and St. Francis Rivers in Missouri and Arkansas. The principal damage was to prospective crops. The total losses reported were as follows: Ohio River, $70,000; Mississippi River, $172,000; and White River, $82,400.

A local flood occurred on the Ninnescah River, a tributary of the Arkansas River, near Cheney, Kans., as the result of excessive rains on the 26th. A total loss of about $30,000 was reported. The North Canadian and South Canadian Rivers, also tributaries of the Arkansas, were



Average Missouri River Stages May to August, inclusive, at Sioux City, Iowa and 5-year progressive stages for the same period 1879–1936

slightly above flood stage at the close of the month. No damage was reported.

West Gulf Drainage.—No flooding of consequence occurred during the month except that exceptionally heavy rains in portions of eastern New Mexico the latter part of May caused unprecedented high stages in the Pecos River. Heavy rains again occurred during the first part of June causing additional rises. A report on this flood will be made in the June issue of the Review.

Colorado River Basin.—A light flood occurred in the Gunnison River in Colorado with no material damage.

San Joaquin River Basin.—The inundated area in this basin increased steadily during the month as the result of melting of the heavy accumulation of snow in the Sierra Nevada foothills. The following report on the conditions in the upper portion of the basin is submitted by the Official in Charge at Fresno, Calif.

Kings River passed above the flood stage on May 12 and remained above that stage to and including May 18. It was again above flood stage on May 21 and 22 and May 28 to 30, inclusive.

These stages were fully anticipated in earlier forecasts of water supply and all protective measures possible had been under way for several weeks. Levees in the Tulare Lake Basin were strengthened but were not sufficient to hold the large run-off into this natural wasteway where attempts have been made to reclaim it and where in seasons of moderate mountain precipitation valuable grain and other crops have been harvested.

The inundated area has steadily increased during the month submerging cotton, beet and grain crops, the latter about ready to harvest. Harvesters are now in the area endeavoring to salvage as much of the crop as possible before rising waters cover it. Maximum diversions for irrigation are being made but a large portion of each day's run-off is reaching the basin and will continue to do so for several weeks more. The history of the summer stages of the stream is that in wet seasons maximum stages occur in June and it is expected that the maximum run-off of 19,000 second-feet on May 15, 1937, may be exceeded, if an unusually warm spell occurs.

The value of prospective crops already lost exceeds $1,000,000 and much additional acreage is in danger.

The Sacramento, Calif., office reports as follows on the high water in the lower San Joaquin River Basin:

The San Joaquin River rose to moderately high stages during the month as a result of the melting of snow over the headwaters of its eastern tributaries. The highest stage reported from Lathrop, Calif., was 13.8 feet on the 28th, or 3.2 feet below the flood stage.

On May 18 local breaks occurred in the levees on the Stanislaus and San Joaquin Rivers near their junction, causing the flooding of about 3,000 acres of farm lands that had been planted to grain, beans, corn, tomatoes, and other crops.

The break on the Stanislaus River was on the south side near its mouth where similar levee failures have occurred during the past 2 or 3 years. Water from this source rapidly spread over about 1,500 acres in the lowest areas of the river junction farms. Adjoining on the south of this tract, but separated by a strip of higher ground, about an equal acreage of low land was inundated on the McMullen tract from a break on the east side of the San Joaquin River. A total of about 30 farm families were compelled to vacate their homes temporarily.

This season's crops in the flooded district will be almost a total loss as further melting of snow will maintain moderately high water levels until midsummer.

The total losses in the lower San Joaquin Basin amounted to about $200,000—of this loss all but about $20,000 resulted from the damage to prospective crops.

Correction for April Monthly Weather Review page 164, Table of Flood Stages:

Crest at Hancock, Md., published as "35.8" feet should be "35.7" feet.

Table of flood stages during May 1937

[All dates in May unless otherwise specified]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC SLOPE DRAINAGE					
Connecticut:	*Feet*			*Feet*	
South Newbury, Vt.	18	Apr. 29	4	20.7	1
		8	9	18.4	9
		15	18	23.5	16
		21	22	19.2	21
White River Junction, Vt.	18	15	16	20.4	15
Montague City, Mass.	28	15	17	31.4	16
Holyoke, Mass.	9	16	17	9.6	16
Hartford, Conn.	16	15	20	21.1	17
James: Columbia, Va.	10	(1)	1	(2)	
Roanoke: Williamston, N. C.	10	Apr. 29	10	13.0	2,3
Tar:					
Tarboro, N. C.	18	Apr. 28	4	22.7	1,2
Greenville, N. C.	13	Apr. 28	6	16.9	3
Neuse:					
Neuse, N. C.	14	(1)	1	(2)	
Smithfield, N. C.	13	(1)	2	(2)	
Goldsboro, N. C.	14	Apr. 27	7	18.4	3
Kinston, N. C.	14	Apr. 29	9	16.3	6
Peedee:					
Mars Bluff Bridge, S. C.	17	Apr. 27	5	20.1	1
Poston, S. C.	18	(1)	8	19.9	3,4
Santee:					
Rimini, S. C.	12	(1)	10	(2)	
		12	17	12.9	16
		19	23	12.5	21
		27	30	12.4	29
Ferguson, S. C.	12	(1)	24	13.9	1,2
Savannah:					
Ellenton, S. C.	14	Apr. 25	11	21.3	3
		15	19	17.0	17
Clyo, Ga.	13	3	14	17.0	7,8
Ogeechee:					
Midville, Ga.	6	2	5	7.7	3
Dover, Ga.	7	4	11	9.8	8

See footnotes at end of table.

Table of flood stages during May 1937—Continued
[All dates in May unless otherwise specified]

River and station	Flood stage	Above flood stages—dates From—	Above flood stages—dates To—	Crest Stage	Crest Date
ATLANTIC SLOPE DRAINAGE—continued					
Ocmulgee:	*Feet*			*Feet*	
Macon, Ga.	18	Apr. 30	2	21.0	Apr. 30
Abbeville, Ga.	11	4	11	14.7	7
Oconee: Milledgeville, Ga.	22	Apr. 30	2	28.7	Apr. 30
Altamaha:					
Charlotte, Ga.	12	3	16	17.9	10, 11
Everett City, Ga.	10	11	19	11.1	15
EAST GULF OF MEXICO DRAINAGE					
Apalachicola: Blountstown, Fla.	15	(1)	16	20.2	5, 6
Oostanaula: Rome, Ga.	25	1	1	25.5	1
Coosa:					
Mayos Bar Lock, Ga.	28	1	1	28.8	1
Gadsden, Ala.	20	Apr. 30	9	24.5	5, 6
Lock No. 4, Lincoln, Ala.	17	Apr. 30	8	20.0	6
Cahaba: Centerville, Ala.	23	1	1	23.8	1
Alabama:					
Montgomery, Ala.	35	2	9	38.8	7
Millers Ferry, Ala.	40	3	13	46.2	9
Black Warrior: Lock No. 10, Tuscaloosa, Ala.	46	1	7	55.0	1
Tombigbee:					
Gainesville, Ala.	36	6	13	41.0	10
Lock No. 4, Demopolis, Ala.	39	3	17	53.3	11, 12
Lock No. 3.	33	2	19	53.9	13
Lock No. 2.	46	5	18	54.6	14
Lock No. 1.	31	4	21	37.0	16, 17
Pearl:					
Edinburg, Miss.	20	7	7	20.1	7
Jackson, Miss.	18	5	16	22.1	13
Pearl River, La.	12	5	9	12.7	7
MISSISSIPPI SYSTEM					
Upper Mississippi Basin					
Illinois:					
Peru, Ill.	17	Apr. 23	9	18.3	5
Peoria, Ill.	18	Apr. 27	12	19.6	6
Havana, Ill.	14	Apr. 21	21	16.5	6–9
Beardstown, Ill.	14	Apr. 27	22	17.3	9–11
Bourbeuse: Union, Mo.	12	4	5	14.8	5
Meramec:					
Sullivan, Mo.	11	1	[3] 5	15.7	4
Valley Park, Mo.	14	2	7	21.2	6
Missouri Basin					
Big Sioux: Akron, Iowa.	12	25	26	13.1	26
Floyd:					
Merrill, Iowa.	13.5	25	26	13.8	25
James, Iowa.	15	26	28	16.9	27
Ohio Basin					
Green:					
Lock No. 4, Woodbury, Ky.	33	6	8	33.9	7
Lock No. 2, Rumsey, Ky.	34	4	12	38.2	9
West Fork of White:					
Anderson, Ind.	8	(1)	[4] 24	(2)	28
		28	29	8.1	
Elliston, Ind.	18	3	6	19.7	5
Edwardsport, Ind.	12	Apr. 29	10	18.0	6
White:					
Petersburg, Ind.	16	3	11	20.7	7
Hazleton, Ind.	16	2	12	21.2	8

Table of flood stages during May 1937—Continued
[All dates in May unless otherwise specified]

River and station	Flood stage	Above flood stages—dates From—	Above flood stages—dates To—	Crest Stage	Crest Date
MISSISSIPPI SYSTEM—continued					
Ohio Basin—Continued					
Wabash:	*Feet*			*Feet*	
La Fayette, Ind.	11	(1)	1	(2)	
		6	6	11.4	6
Covington, Ind.	16	(1)	2	(2)	
Terre Haute, Ind.	14	Apr. 24	6	15.9	3
Vincennes, Ind.	14	2	9	16.1	5, 6
Mt. Carmel, Ill.	19	4	11	20.8	8
New Harmony, Ind.	15	5	12	16.3	9, 10
Cumberland: Lock F., Eddyville, Ky.	50	4	9	52.6	8
Ohio:					
Dam No. 25, near Addison, Ohio.	43	(1)	1	(2)	
Point Pleasant, W. Va.	40	(1)	1	(2)	
Dam No. 47, Newburgh, Ind.	38	3	9	41.2	5, 6
Evansville, Ind.	35	3	9	38.8	6
Dam No. 48, near Henderson, Ky.	38	4	9	40.2	6, 7
Dam No. 49, near Uniontown, Ky.	37	5	11	39.8	8
Dam No. 50, Fords Ferry, Ky.	34	3	14	42.4	8, 9
Dam No. 51, Golconda, Ill.	40	7	11	41.1	9
Dam No. 52, Brookport, Ill.	37	3	14	44.1	9
Dam No. 53, near Mound City, Ill.	42	3	15	50.0	10
Cairo, Ill.	40	3	16	48.7	
White Basin					
Black:					
Poplar Bluff, Mo.	14	2	2	14.0	2
		4	5	14.5	4
Black Rock, Ark.	14	5	11	15.2	8, 9
White:					
Calico Rock, Ark.	18	2	3	21.8	2, 3
Batesville, Ark.	23	3	4	26.6	3
Georgetown, Ark.	21	7	16	22.2	11
Clarendon, Ark.	26	13	23	26.7	17–19
Arkansas Basin					
North Canadian:					
Woodward, Okla.	5	31	June 1	5.0	31, June 1
Canton, Okla.	6	30	30	6.0	30
Yukon, Okla.	8	31	31	9.2	31
Canadian:					
Camargo, Okla.	9	30	30	10.6	30
Union City, Okla.	7	30	31	13.8	31
Petit Jean: Danville, Ark.	20	3	4	21.4	3
Lower Mississippi Basin					
Big Lake Outlet: Manila, Ark.	10	4	18	12.5	9, 10
St. Francis:					
Fisk, Mo.	20	1	9	23.3	5, 6
St. Francis, Ark.	18	5	16	21.0	9
Mississippi:					
New Madrid, Mo.	34	6	15	37.9	10, 11
Memphis, Tenn.	34	13	17	34.8	15
Helena, Ark.	44	14	20	45.2	17, 18
WEST GULF OF MEXICO DRAINAGE					
Rio Grande:					
Espanola, N. Mex.	7	(1)	(2)	8.3	11, 13–16
Albuquerque, N. Mex.	4	15	15	4.0	15
		24	25	4.2	24
GULF OF CALIFORNIA DRAINAGE					
North Fork of Gunnison: Paonia, Colo.	9	10	11	9.0	10, 11
		16	16	9.1	16
Gunnison: Delta, Colo.	9	6	6	9.0	6
		8	20	10.8	15

[1] Continued from previous month.
[2] Crest occurred during previous month.
[3] Fell 1.2 feet below flood stage on 2d.
[4] Fell slightly below flood stage on 18th, 21st, and 23d.
[5] Continued into June.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, I. R. TANNEHILL, in charge]

NORTH ATLANTIC OCEAN, MAY 1937

By H. C. HUNTER

Atmospheric pressure.—The pressure averaged higher than normal over most eastern and south-central portions, Lerwick in the Shetland Islands showing an excess for the month of 0.19 inch. The waters near Canada and Newfoundland likewise had pressure higher than normal. A moderate deficiency was noted over the southwestern part of the North Atlantic and a somewhat greater one near Greenland and Iceland; Reykjavik, in the latter island, had 0.18 deficiency. Over this far-northern area the pressure averaged considerably lower during the first half of the month than during the second half.

The extremes of pressure among vessel reports at hand are 30.70 and 29.25 inches. The higher mark was noted on the British steamship *Matina* on the morning of the 18th, about 200 miles northwest of Horta. The lower reading was made on the Danish steamship *Tennessee*, on the following day, near latitude 57° N., longitude 21° W. However, the pressure on the 7th at Julianehaab, Greenland, was much lower, as indicated in table 1.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, May 1937*

Stations	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.79	−0.06	30.50	22	28.88	7
Reykjavik, Iceland	29.74	−.18	30.18	23, 24	29.21	3
Lerwick, Shetland Islands	29.99	+.19	30.32	1	29.62	20, 31
Valencia, Ireland	29.95	.00	30.42	1	29.62	9, 20, 22
Lisbon, Portugal	30.10	+.13	30.33	5, 6	29.86	16
Madeira	30.10	+.09	30.39	12	29.83	1
Horta, Azores	30.20	+.04	30.58	18	29.80	26
Belle Isle, Newfoundland	30.02	+.13	30.44	15	29.44	31
Halifax, Nova Scotia	29.99	+.02	30.36	1, 2	29.72	20
Nantucket	29.96	−.03	30.31	1	29.67	20
Hatteras	30.01	.00	30.31	1	29.75	29
Bermuda	30.04	−.07	30.24	13, 14	29.62	22
Turks Island	29.94	−.06	30.02	13	29.84	25
Key West	29.95	−.02	30.06	12	29.87	29
New Orleans	30.00	+.03	30.12	17	29.84	5

NOTE.—All data based on a. m. observations only, with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—There was but little storm activity over the North Atlantic. In only two instances have force-10 winds been noted and in no case did a force exceed 10.

A LOW from the vicinity of Bermuda moved first northward then northeastward and was sufficiently strong on the 1st and 2d to cause gale-force winds between the longitude of Nova Scotia and the western edge of the Grand Banks, one vessel recording force 10. By the evening of the 3d the LOW was centered about 400 miles south of Cape Race, with decreasing intensity.

The other force-10 wind was encountered considerably farther to northward and in about the longitude of Iceland. A LOW central just to southwest of that island on the 18th took a southeastward course, and in connection with high pressure near and to westward of the Azores caused gales over the region near and to northward of 50° and from about 15° to 35° west longitude. After noon of the 19th the LOW lost energy and gale reports became fewer.

The Belgian steamship *Astrida*, from Santos toward Antwerp, met intensified northeast trades from the 18th to 20th, when off the west coast of Africa a considerable distance to southwest of the Canaries. The greatest strength was estimated as 8.

Fog.—There was a marked increase over April in the prevalence of fog, but it was only about as common as usual during May. The general vicinity of the Grand Banks and the region to the westward, as far as New England, had most frequent fog, the 5° square, 40° to 45° N., 50° to 55° W., with 17 days, well distributed through the month, leading all other squares in amount. Near Nova Scotia and New England there was practically no fog before the 7th; also the period 11th to 16th, inclusive, had comparatively little. On the other hand, the vicinity of the New Jersey coast had hardly any fog during the latter half of the month.

In coast regions near and to southwestward of Hatteras the month seems to have been entirely free from fog, but the waters near Bermuda had a little about the 8th.

Over the eastern half of the North Atlantic fog was almost confined to the portion close to and north of the forty-fifth parallel of latitude. Near the chief steamship lanes between the ports of Britain and France and the thirtieth meridian the days about the 7th and 8th were most noteworthy for fog.

During the first 2 days of May two serious accidents due to fog occurred in waters adjacent to northern Europe and about a week later two others occurred there. Apparently no lives were lost in these mishaps, but two vessels sank and a third was beached to keep it from sinking.

For the western part of the North Atlantic important accidents resulting from fog came much later in the month. A collision occurred in the St. Lawrence River, below Quebec, on the 22d, and on the 27th or 28th the tank steampship *A. C. Bedford* and the Swedish motorship *Kungsholm* collided near Nantucket Lightship. All the vessels involved in these two collisions were able to make port.

OCEAN GALES AND STORMS, MAY 1937

Vessel	Voyage		Position at time of lowest barometer		Gale began May	Time of lowest barometer May	Gale ended May	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Inches*					
Emile Francqui, Belg. S. S.	Antwerp	New York	41 10 N.	61 00 W.	1	1a, 1	2	29.86	NE.	NE, 8	NNE.	NE, 10	NE-NNE.
Independence Hall, Am. S. S.	New York	Havre	39 30 N.	64 00 W.	1	2a, 1	1	29.78	N.	NNE.	NNE.	NNE, 8	None.
Silverwalnut, Br. M. S.	Dakar	Halifax	41 07 N.	57 31 W.	2	1a, 2	3	29.90	ENE.	ENE, 7	ENE.	ENE, 8	E-ENE.
Lady Somers, Br. M. S.	Montreal	Bermuda	39 21 N.	63 30 W.	1	1a, 2	2	29.79	NE.	ESE, 6	ESE.	NE, 9	NE-SE-ESE.
Montreal City, Br. S. S.	Bristol	Norfolk	41 56 N.	60 10 W.	1	8a, 2	2	30.01	ENE.	ENE, 8	NE.	ENE, 9	
Narbo, Am. S. S.	New Orleans	Havre	37 38 N.	66 07 W.	[1] 30	10a, 2	3	29.69	NNE.	NNE, 9	NNE.	NNE, 9	None.
Monarch of Bermuda, Br. S. S.	New York	Bermuda	34 42 N.	67 18 W.	2	8p, 2	2	29.95	NNE.	NE, 8	NNE.	NNE, 8	NE-NNW.
American Merchant, Am. S. S.	do	London	40 30 N.	62 18 W.	2	9p, 2	2	29.76	N.	NE, 7	NE.	NE, 9	
Sagaporack, Am. S. S.	Copenhagen	New York	55 35 N.	23 35 W.	8	4p, 8	9	29.52	SSE.	SE, 8	NW.	SW, 8	SSE-SE-SW.
Independence Hall, Am. S. S.	New York	Havre	48 08 N.	23 35 W.	9	4p, 9	9	29.86	NW.	NW, 9	N.	NW, 9	NW-N.
Paris, Fr. S. S.	do	Plymouth	48 35 N.	20 02 W.	9	8p, 9	9	29.62	NW.	NNW, 9	NNE.	NW, 9	NNW-N.
Livenza, Ital. S. S.	Gibraltar	New York	36 15 N.	57 10 W.	10	8a, 10	10	30.02		S, 8		S, 8	
Colombia, Am. S. S.	New York	Cape Haitien	29 42 N.	74 00 W.	15	7a, 15	15	29.77	SE.	SE, 8	SE.	SE, 8	SE-SW.
Astrida, Belg. S. S.	Santos	Antwerp	16 30 N.	25 53 W.	18	4a, 19	20	[2] 30.00	NE.	NE, 7	NE.	NE, 8	None.
Adria, Ger. M. S.	Hull	Philadelphia	48 45 N.	18 05 W.	20	11a, 19	20	29.75	NW.	NW, 5		NW, 8	
Tennessee, Dan. S. S.	New York	Oslo	57 01 N.	21 07 W.	17	11a, 19	19	29.25	W.	WNW, 8	W.	W, 10	W-N.
Labette, Am. S. S.	New Orleans	Avonmouth	49 05 N.	24 28 W.	20	11a, 20	20	29.94	NW.	NNW, 7	NNW.	NW, 8	
Tennessee, Dan. S. S.	New York	Oslo	58 32 N.	1 15 W.	21	2p, 21	21	29.65	E.	E, 7	S.	S, 9	E-SE.
Adria, Ger. M. S.	Hull	Philadelphia	46 52 N.	31 14 W.	22	10a, 22	23	29.75	NW.	NW, 9		NNW, 9	
Black Hawk, Am. S. S.	Rotterdam	New York	48 59 N.	13 54 W.	24	4a, 24	24	29.35	SSE.	S, 8	SW.	SSW, 9	SSE-SSW.
Collamer, Am. S. S.	New York	Havre	[1] 47 13 N.	27 27 W.	22	4a, 24	23	29.57	NNW.	NW, 5	NW.	NW, 8	
Circe Shell, Br. M. S.	Curacao	Rotterdam	46 54 N.	24 53 W.	28	10a, 27	28	29.49		S, 5		SW, 8	S-SW.
Amsterdam, Du. S. S.	Steilene	Baytown	[2] 48 27 N.	23 05 W.	27	4a, 28	28	29.28	SSW.	WSW, 9	W.	WSW, 9	SW-W.
American Trader, Am. S. S.	New York	London	47 40 N.	25 00 W.	27	4a, 28	29	29.48	N.	W, 7	SW.	WSW, 8	W-WSW.
NORTH PACIFIC OCEAN													
Pres. Lincoln, Am. S. S.	Honolulu	Yokohama	35 00 N.	143 00 E.	2	11p, 2	2	29.51	S.	SSW, 6	SW.	S, 8	S-SW.
Toorak, Br. S. S.	San Francisco	Onagawa	37 54 N.	160 12 E.	2	11a, 4	5	29.51	NNE.	SW, 6	WNW.	ESE, 8	S-WSW.
Illinois, Am. S. S.	Manila	San Francisco	38 12 N.	123 18 W.	4	4p, 5	5	29.82	NNW.	WNW, 3	NW.	NNW, 9	
Irisbank, Br. M. S.	San Francisco	Manila	37 24 N.	123 48 W.	4	2a, 5	5	29.90	NW.	NNW, 8	WNW.	NNW, 9	
General Pershing, Am. S. S.	Portland, Oreg.	Yokohama	49 50 N.	178 50 W.	5	3p, 5	6	28.73	ESE.	ESE, 6	NNW.	E, 9	ESE-N.
Empress of Russia, Br. S. S.	Victoria, B. C.	do	51 24 N.	173 00 W.	5	1a, 6	6	28.90	SE.	NE, 5	N.	E, 9	WSW-NE.
Irisbank, Br. M. S.	San Francisco	Manila	36 24 N.	129 42 W.	6	4a, 6	7	29.89	W.	SW, 5	NW.	W, 9	SW-W.
Zuiyo Maru, Jap. S. S.	Yokohama	Port San Luis	42 52 N.	159 13 E.	8	11p, 7	9	29.12		SSW, 4		W, 8	
Pres. Van Buren, Am. S. S.	Honolulu	Kobe	32 36 N.	167 12 E.	8	6p, 8	8	29.63	SW.	NW, 8	N.	SW, 8	SW-NW.
General Pershing, Am. S. S.	Portland, Oreg.	Yokohama	48 41 N.	165 40 E.	8	Noon, 8	9	28.83	NNW.	E, 4	NNW.	NNW, 8	SE-E-NNW.
Talthybius, Br. S. S.	Yokohama	Victoria, B. C.	49 48 N.	172 36 W.	8	1a, 9	8	29.02	SE.	S, 4	SE.	SE, 8	
Pleasantville, Nor. M. S.	Hong Kong	Los Angeles	44 27 N.	179 12 E.	8	4a, 9	9	29.17	WSW.	WSW, 8	NW.	W, 9	
Omrosan Maru, Jap. M. S.	Osaka	do	41 55 N.	159 28 W.	9	6p, 10	10	29.49	W.	W, 7	W.	W, 8	
Pres. Jackson, Am. S. S.	Seattle	Yokohama	51 08 N.	138 00 W.	9	8a, 10	10	28.56	SE.	SSW, 3	E.	E, 10	E-SSW-N.
Empress of Asia, Br. S. S.	Yokohama	Vancouver	47 32 N.	172 18 E.	12	Noon, 12	12	29.18	SE.	E, 8	E.	ESE, 8	E-SE.
Michigan, Am. S. S.	Manila	San Francisco	41 12 N.	179 12 E.	12	Noon, 12	13	29.75	W.	SSE, 7	NW.	WNW, 8	SE-W.
General Lee, Am. S. S.	Yokohama	do	42 03 N.	157 28 E.	17	8p, 17	18	29.33	SSW.	WSW, 5	NW.	N, 9	SW-WSW-N.
Golden Tide, Am. S. S.	do	do	41 45 N.	164 22 E.	18	6a, 18	18	29.24	NW.	SW, 7	NW.	NNW, 11	SW-NNW.
Fujisan Maru, Jap. M. S.	Tokuyama	Los Angeles	44 34 N.	170 35 W.	18	6a, 18	19	29.27	WSW.	S, 6	W.	WSW, 8	S-WSW.
Bonneville, Nor. M. S.	Osaka	Portland, Oreg.	[2] 48 54 N.	179 02 E.	19	4a, 19	18	29.13	NNE.	N, 8	W.	NW, 9	NNE-NNW.
Hakushika Maru, Jap. S. S.	Nagoya	Astoria	48 45 N.	168 44 W.	18	4p, 18	19	28.78	SSE.	S, 6	W.	W, 8	SE-SW.
Toorak, Br. S. S.	Itosaki	Los Angeles	36 16 N.	148 06 E.	18	8a, 19	19	29.71	SW.	SSW, 7	NNW.	W, 8	SSW-WNW.
Golden Tide, Am. S. S.	Yokohama	San Francisco	41 28 N.	176 30 E.	20	7p, 20	20	29.69	S.	S, 9	S.	S, 9	S-W.
Pres. McKinley, Am. S. S.	do	Victoria	48 21 N.	175 23 E.	20	10a, 21	21	28.95	S.	SW, 6	SW.	WSW, 8	SW-WNW.
Asama Maru, Jap. M. S.	do	Honolulu	34 45 N.	144 14 E.	21	8a, 21	22	29.58	SW.	SW, 8	W.	SW, 8	SSW-SW.
Toorak, Br. S. S.	Itosaki	Los Angeles	39 26 N.	163 27 E.	21	4a, 22	24	29.09	S.	SSW, 9	W.	SSW, 9	S-SW.
Golden Tide, Am. S. S.	Yokohama	San Francisco	[1] 41 19 N.	171 32 W.	22	5a, 22	22	29.56	S.	SSW, 8	S.	S, 8	S-SSW-S.
Indianan, Am. S. S.	Los Angeles	Balboa	16 09 N.	99 45 W.	25	3p, 25	25	29.59	NE.	SW, 7	SW.	SSW, 9	SE-SW.
Susan V. Luckenbach, Am. S. S.	Los Angeles	Balboa	15 56 N.	98 41 W.	25	3a, 25	25	29.75	ESE.	ESE, 7	NNE.	ENE, 8	ESE-ENE.
Texas, Am. S. S.	Bugo	San Francisco	34 07 N.	161 09 E.	25	4a, 26	26	29.79	SE.	SW, 6	SW.	S, 8	S-SW.
Toorak, Br. S. S.	Itosaki	Los Angeles	42 48 N.	158 06 W.	26	4p, 27	27	29.98	S.	SSW, 9	SSW.	SSW, 9	S-SSW.
Texas, Am. S. S.	Bugo	San Francisco	41 30 N.	174 00 W.	29	2a, 30	30	29.13	ESE.	N, 10	NNW.	ESE, 10	WSW-N.
San Ramon Maru, Jap. M. S.	Yokohama	do	[2] 46 29 N.	157 57 W.	31	9p, 30	31	28.98	W.	N, 6	W.	W, 8	N-NW.

[1] April.
[2] Barometer uncorrected.
[3] Position approximate.

NORTH PACIFIC OCEAN, MAY 1937

By WILLIS E. HURD

Atmospheric pressure.—The Aleutian LOW was more firmly established over the extreme northern waters of the North Pacific Ocean in May 1937, than during any previous month of the year: at Dutch Harbor the average pressure, 29.59 inches, was 0.25 inch below the normal for the month. Barometer readings below 29 inches were observed on several days over the central and western parts of the northern routes, the American steamer *General Pershing* reporting a reading of 28.73 on the 5th near 50° N., 178° W. However, the lowest reading of the month, 28.56, reported by the American steamer *President Jackson* on the 10th near 51° N., 138° W., was in a region much less frequented by deep cyclonic storms this month than were the higher latitudes from midocean westward.

High pressure prevailed from the northwest coast of the United States over a considerable region southwestward to the Hawaiian Islands and thence westward into East longitudes. In this region Midway Island had an average barometer of 30.14, which is 0.09 inch above the normal of the month.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, May 1937, at selected stations*

Station	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow	29.93	−0.16	30.22	6	29.62	30
Dutch Harbor	29.59	−.25	30.50	1	28.96	24
St. Paul	29.64	−.20	30.18	1	29.98	17
Kodiak	29.71	−.13	30.34	1	29.36	11, 24, 25
Juneau	29.94	−.05	30.34	5	29.25	10
Tatoosh Island	30.07	+.06	30.44	4	29.66	16
San Francisco	29.96	−.03	30.23	7	29.71	29
Mazatlan	29.85	.00	29.96	10	29.74	26
Honolulu	30.06	+.01	30.16	8	29.87	2
Midway Island	30.14	+.09	30.28	14, 15	30.00	29
Guam	29.88	.00	29.92	{10, 15, 21, 24, 28}	29.83	{3, 5, 12, 31}
Manila	29.82	+.05	29.89	24	29.71	31
Hong Kong	29.79	+.01	29.92	3	29.64	13
Nemuro [1]						

[1] Data incomplete.

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

Cyclones and gales.—Most of the cyclonic activity this month was of the Aleutian LOW type with deep and well-developed centers frequently appearing in upper-central and western waters, and much less frequently over the northeastern part of the ocean. The greater part of the month's storminess was therefore experienced by vessels over the western two-thirds of the northern and central routes. Most extratropical gales reported were of forces 8–9, but on three dates winds of force 10 were encountered, and on one date a northwesterly gale of force 11 occurred. This was reported on the 18th near 42° N., 164° E., by the American steamer *Golden Tide*.

During the first 4 days of May a cyclone lay over extreme northwestern waters and was the cause of fresh gales off the east coast of Japan. The disturbance moved rapidly eastward on the 5th, carrying low pressures and fresh to strong gales over a great expanse of ocean in the vicinity of the Aleutian Islands.

On the 8th and 9th another deep LOW spread over Aleutian waters, whence it moved with great rapidity into the Gulf of Alaska, where, on the 10th, the steamship *President Jackson* had a force-10 gale near 51° N., 138° W., with the low barometer previously referred to.

Subsequently, with the fluctuations of the Aleutian cyclone, stormy conditions continued intermittently in northern waters until the end of the month, and are best shown by the table of gales.

In eastern Japanese waters gales were reported on the 2d, 3d, 19th, and 22d; in middle California waters, on the 5th and 6th.

The New York Maritime Register and press reports state that the British steamship *City of Singapore, which* left Los Angeles for Manila on May 9, returned to port late on the following day in a battered condition and with 20 injured seamen, the result of a sudden encounter with a storm of hurricane force a few hours out from harbor. Ship weather reports available at the present time do not show this storm, and it must have been of local character.

Tropical cyclone off the Pacific Mexican coast.—A small but violent cyclone occurred off the coast of Mexico to the southward of Acapulco on May 25. So far as at present reported, most if not all the rough weather in connection with it was confined to the area lying between the coast and latitude 15° N. and between the ninety-eighth and one-hundred and first meridians.

At the morning observation of May 25 the American steamers *Indianan* and *Susan V. Luckenbach* reported moderate gales (force 7), the former from northeast, in 15°54′ N., 99°24′ W., barometer 29.63; the latter from east-southeast, in 16°05′ N., 99°00′ W., barometer 29.75. The highest wind reported by these ships was of force 9, encountered by the *Indianan* shortly after local noon, a little distance to the northward of her earlier position.

The northbound Norwegian steamship *Kattegat*, as noted in a special report from the ship, was in heavy rain to "blinding rainsqualls" from 8 a. m. to 12 noon (local), with southeast to south-southwest wind, force 4–5. Her noon position was in 15°59′ N., 99°04′ W. At 3 p. m. she was struck by a heavy and damaging sea, and 10 minutes later was hove to south for bare steering speed into the wind. At 4 p. m. the wind was south, force 9–10, with "sea mounting tremendously." From 5 to 6 p. m. the gale was at its worst, with hurricane squalls from from southeast, heavy rain, and no visibility "sea sweeping over the ship." At 8 p. m. the winds were decreasing, though still of gale force; at 11 p. m. the ship put back on her course.

Mr. E. I. Croft, observing officer on the steamship *Antigua* which at local noon was south of Cape Corrientes, reporting on the weather messages picked up by radio during the 25th, said the storm apparently moved northward directly upon Acapulco, which it struck late in the afternoon. The Panama Pacific liner *Virginia*, according to Mr. Croft, encountered southwest winds of force 10–11 outside of Acapulco at 5 p. m. and, unable to make port in the heavy weather which threatened to break her, put back to sea.

The storm went inland during the late afternoon or early night. It appeared thereafter to have crossed southern Mexico, as on the evening of the 26th and the morning of the 27th a depression appeared over the southwestern Gulf of Mexico, with lowest barometer at or near Veracruz.

Fog.—Widely-scattered fogs were reported along the northern steamship routes on 12 days; along the middle routes, between 30°–40° N., 175° W.–145° E., on 11 days; off the China coast on 4 days; off the California coast on 4 days; and off Lower California on 7 days.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

TABLE 1.—*Condensed climatological summary of temperature and precipitation by sections, May 1937*

[For description of tables and charts, see REVIEW, January, p. 35]

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	72.9	+1.6	Dothan	104	30	2 stations	40	[1]7	4.32	+0.20	Mobile Airport	8.22	Seale	1.04
Arizona	68.7	+1.1	Quartzsite	114	14	do	19	1	.29	−.01	Fort Valley	1.63	7 stations	.00
Arkansas	71.1	+2.0	2 stations	99	[1]28	Dutton	36	14	3.63	−1.36	Lutherville	6.71	Crossett	1.28
California	62.5	+1.1	do	113	[1]14	Boca	14	16	.23	−.73	Crescent City (near)	5.78	61 stations	.00
Colorado	55.7	+3.5	Las Animas	102	17	2 stations	12	3	1.20	−.69	Holyoke	3.11	Cheyenne Wells	T
Florida	75.4	−.2	Blountstown	103	30	Garniers (near)	48	[1]16	3.41	−.57	Fort Pierce	9.90	Lake Placid	.10
Georgia	71.9	+.3	Bainbridge	102	30	Blairsville	36	9	2.17	−1.28	Rome	5.35	Satilla Forest	.45
Idaho	55.1	+2.1	Challis	95	22	2 stations	18	23	.75	−.91	Roland	1.82	3 stations	.00
Illinois	63.8	+1.3	6 stations	96	[1]30	Aurora	30	15	3.24	−.87	Walnut	6.78	Chicago	1.64
Indiana	62.7	+.5	Elliston	101	30	La Porte	30	10	3.50	−.50	Boonville	6.45	Indianapolis	1.58
Iowa	61.8	+1.7	Millerton	95	30	Estherville	27	14	4.07	.00	Des Moines	7.13	Bonaporte (near)	1.88
Kansas	66.7	+2.9	Oberlin	102	19	3 stations	32	14	3.15	−.63	Norwich	12.88	Syracuse	.29
Kentucky	65.2	−.2	Greensburg	99	31	4 stations	36	[1]7	4.01	+.02	Williamsburg	9.66	Jenkins	1.78
Louisiana	74.7	+1.0	3 stations	97	[1]25	2 stations	47	15	3.18	−1.42	Pollock	6.57	Minden	.77
Maryland-Delaware	63.2	+.7	do	95	31	Oakland, Md	27	11	3.44	+.03	Dundalk, Md	6.91	Emmitsburg, Md	1.59
Michigan	55.3	+1.3	Saranac	97	30	Vanderbilt	16	15	2.37	−.83	Bay City	5.05	Wolverine	.53
Minnesota	57.3	+2.1	Wheaton	97	29	Roseau	21	9	3.83	+.68	Chaska	8.55	Moorhead	1.37
Mississippi	74.0	+2.2	Aberdeen	101	31	Duck Hill	43	15	3.39	−.98	West Point	6.34	Moorhead	1.20
Missouri	66.2	+1.8	Caruthersville	98	[1]27	2 stations	34	15	3.86	−.89	Bowling Green	6.74	Tarkio	1.04
Montana	55.0	+3.2	Rock Springs (near)	105	28	3 stations	18	[1]17	.57	−1.57	Belton	2.03	Lustre (near)	.00
Nebraska	62.2	+3.0	Fairbury	99	28	Hay Springs	26	13	2.60	−.83	Grand Island	5.27	North Platte	.64
Nevada	60.0	+4.5	Las Vegas Airport	107	[1]15	Sheldon	17	7	.48	−.39	Lamoille	2.80	5 stations	.00
New England	57.3	+2.2	3 stations	96	31	Chelsea, Vt	24	1	4.72	+1.37	Franklin, N. H	9.92	Rockport, Mass	1.80
New Jersey	62.5	+2.1	Belvidere	96	31	Canoe Brook	28	1	3.12	−.61	Woodcliff Lake	4.82	Long Branch	1.60
New Mexico	61.2	+1.6	Hagerman	104	15	Luna Ranger Station	12	1	2.97	+1.76	Ragland	9.35	2 stations	.00
New York	57.7	+1.6	2 stations	97	31	Indian Lake	22	1	3.84	+.37	Avon	5.84	Patchogue	1.18
North Carolina	66.8	.0	do	98	[1]27	Mount Mitchell	27	15	2.18	−1.89	Salisbury	5.18	Southport	.21
North Dakota	56.9	+3.5	Maddock	99	28	Crosby	19	13	1.76	−.55	Hillsboro	4.37	Howard	.10
Ohio	60.5	.0	2 stations	96	31	Millport	29	11	3.70	+.05	McConnelsville	6.85	Bellpoint	1.46
Oklahoma	70.9	+2.6	Hollis	102	21	2 stations	38	[1]1	3.43	−1.27	McAlester	7.83	Kingfisher	1.11
Oregon	54.1	+.9	2 stations	93	[1]2	Austin	7	5	1.15	−.59	Brookings	5.58	3 stations	T
Pennsylvania	60.7	+1.1	Carlisle	96	22	Hyndman	24	19	3.39	−.48	Blairsville	5.67	Hamburg	1.47
South Carolina	70.8	−.1	Camden	99	28	Long Creek (near)	38	7	2.05	−1.52	Caesars Head	4.07	Yemassee	.24
South Dakota	60.0	+3.7	Cottonwood	99	28	Ludlow	24	13	2.31	−.56	Milbank	5.93	Castlewood	1.00
Tennessee	67.9	+1.0	3 stations	100	31	Erwin	35	11	4.79	+.68	Ashwood	9.70	Corrington	2.15
Texas	74.8	+1.8	Presidio	106	[1]16	Clint	36	1	2.25	−1.39	San Antonio	7.68	2 stations	.00
Utah	58.6	+3.2	Hanksville	99	16	Silver Lake	12	1	1.24	+.03	Moon Lake	2.93	do	T
Virginia	64.1	.0	4 stations	95	[1]22	Burkes Garden	28	11	2.78	−.94	Fredericksburg	4.73	Glen Lyn	.84
Washington	55.1	+.7	Lowden	93	[1]2	Stockdill Ranch	21	6	1.24	−.76	Spruce	7.94	2 stations	.00
West Virginia	61.4	−.3	Hastings	97	31	3 stations	28	[1]1	3.58	−.39	Bens Run	7.17	Bluefield	.94
Wisconsin	56.8	+1.6	Wisconsin Dells	96	30	Big St. Germain Dam	11	14	3.04	−.53	Grantsburg	7.37	Oconto	.76
Wyoming	52.3	+2.8	2 stations	95	[1]18	Lake Yellowstone	10	[1]1	1.59	−.48	Knowles (near Aladdin)	3.87	Buffalo Ranch	.31
Alaska (April)	24.5	−2.5	Seclusion Harbor	63	24	Shishmaref	−30	8	1.70	+.12	Baranoff	14.17	Barrow	.10
Hawaii	72.1	.0	Kaanapali	90	3	Kanalohuluhulu	41	30	9.10	+2.69	2 stations	36.00	Waiopai Ranch	.00
Puerto Rico	77.5	+.7	Dorado	96	31	3 stations	56	[1]1	5.92	−1.67	Lares	20.56	Bayamon	.52

[1] Other dates also.

TABLE 2.—*Climatological data for Weather Bureau stations, May 1937*

[Compiled by Annie E. Small by official authority, U. S. Weather Bureau]

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch, or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
New England							**57.1**	**+2.5**										**74**	**3.56**	**+0.4**										**5.8**		
Eastport	76	67	85	29.88	29.96	0.00	51.0	+3.3	90	31	59	37	15	43	40	46	43	80	2.20	−0.8	12	9.3	sw.	41	e.	20	5	7	19	7.2	0.0	0.0
Greenville, Maine	1,070	6	40																												
Portland, Maine	103	82	117	29.83	29.95	−.02	56.2	+2.9	96	31	64	39	15	48	36	49	43	68	5.58	+2.2	13	8.0	e.	23	se.	15	14	5	12	5.1	.0	.0
Concord	289	60					57.6	+3.3	93	31	70	36	3	45	47				5.21	+2.0	10		ne.				12	6	13		.0	.0
Burlington	403	11	48	29.49	29.93	−.04	57.0	+.5	88	31	68	32	16	46	36	51	46	70	4.27	+1.4	14	7.6	nw.	30	se.	12	8	6	17	6.2	.0	.0
Northfield	876	12	60	29.01	29.96	−.01	54.1	+1.3	90	31	67	28	16	41	47	49	45	73	5.32	+2.6	13	6.8	s.	21	s.	12	9	7	15	6.6	.0	.0
Boston [1]	29	31	60	29.91	29.94	−.04	59.1	+2.0	93	31	68	42	11	50	32	52	47	70	2.52	−.7	13	9.3	w.	28	ne.	2	9	8	14	6.1	.0	.0
Nantucket	12	14	90	29.95	29.96	−.03	54.7	+2.4	75	23	61	42	1	48	25	50	48	83	2.16	−.7	10	13.4	sw.	34	ne.	2	13	4	14	5.9	.0	.0
Block Island	26	11	46	29.93	29.96	−.03	55.6	+2.8	72	4	62	42	1	49	24	52	50	88	3.26	−.2	11	13.6	sw.	30	nw.	10	6	12	13	6.0	.0	.0
Providence	160	215	251	29.78	29.96	−.02	60.0	+1.5	91	31	70	40	11	50	38	53	46	66	2.54	−.4	12	10.5	nw.	32	s.	15	11	10	10	5.0	.0	.0
Hartford	159	66	100	29.79	29.96	−.02	61.4	+3.9	92	31	73	39	1	50	39				4.13	+.5	10	7.8	s.	25	s.	5	12	7	12	5.2	.0	.0
New Haven	106	74	153	29.85	29.96	−.03	61.3	+3.4	90	31	71	41	11	52	33	54	47	65	1.98	−1.7	11	8.0	s.	27	ne.	2	9	12	10	5.2	.0	.0
Middle Atlantic States							**63.8**	**+1.7**										**65**	**2.77**	**−0.7**									**4.7**		
Albany	97	97	112	29.84	29.94	−.04	61.8	+2.5	92	31	73	38	11	50	39	53	46	62	4.13	+1.2	12	6.9	s.	21	s.	12	9	11	11	5.6	.0	.0
Binghamton	871	57	79	29.05	29.98	.00	59.2	+1.8	89	31	71	34	16	47	38				3.02	−.3	16	6.0	nw.	24	sw.	17	8	7	16	6.5	.0	.0
New York	314	415	454	29.63	29.96	−.03	63.3	+2.7	88	31	73	44	1	54	30	54	48	65	2.64	−.6	9	13.0	s.	49	nw.	23	13	10	8	5.0	.0	.0
Harrisburg	374	94	104	29.57	29.97	−.01	63.4	+1.6	92	22	74	43	1	53	36	55	48	63	3.19	−.2	11	6.7	w.	25	w.	17	11	14	6	4.4	.0	.0
Philadelphia	114	174	367	29.87	29.99	.00	65.3	+2.4	90	22	75	46	1	55	31	56	49	61	2.62	−.6	9	12.0	sw.	43	sw.	22	13	9	9	4.8	.0	.0
Reading	323	283	306	29.62	29.97	.....	64.2	+1.7	89	31	75	42	1	54	33	55	48	62	2.61	−1.1	13	10.0	nw.	50	sw.	22	9	15	7	5.0	.0	.0
Scranton	805	72	104	29.11	29.96	−.02	60.7	+1.3	90	31	73	36	16	49	36	52	45	61	2.66	−.6	11	6.2	n.	24	nw.	17	11	13	7	4.8	.0	.0
Atlantic City	52	37	172	29.93	29.99	+.01	60.8	+2.7	86	27	68	43	1	53	28	55	51	74	1.85	−1.2	9	14.9	s.	33	nw.	27	9	15	7	5.2	.0	.0
Sandy Hook	22	10	57	29.94	29.96	.....	62.1	+3.7	86	31	70	45	1	54	27	55	51	73	1.94	−1.8	11	11.8	s.	36	s.	12	12	12	7	4.5	.0	.0
Trenton	190	88	106	29.76	29.97	.....	63.9	+2.8	90	31	75	42	1	52	33	55	48	62	2.86	−.2	12	9.2	s.	27	n.	19	15	9	7	4.3	.0	.0
Baltimore	123	100	215	29.85	29.98	−.01	66.8	+2.4	94	22	77	45	1	57	33	57	50	61	3.27	−.3	13	9.9	sw.	40	nw.	26	14	9	8	4.5	.0	.0
Washington	112	62	85	29.86	29.98	−.02	65.8	+2.1	91	22	77	40	1	55	32	57	51	64	4.02	+.3	12	6.7	nw.	30	w.	13	11	14	6	4.4	.0	.0
Cape Henry	18	8	54	29.98	30.00	.....	65.4	+1.2	94	22	74	45	4	57	31	60	56	74	1.58	−2.0	4	11.0	sw.	35	ne.	28	13	16	2	3.6	.0	.0
Lynchburg	686	148	184	29.28	30.02	+.02	66.4	−.9	93	31	79	37	1	54	36	57	51	64	2.93	−.7	10	6.7	nw.	25	nw.	26	14	13	4	3.9	.0	.0
Norfolk	91	80	125	29.91	30.01	+.01	67.6	+1.4	92	22	77	45	1	58	29	59	54	67	3.35	−.5	5	9.3	sw.	41	nw.	28	12	15	4	4.5	.0	.0
Richmond	144	11	52	29.86	30.00	+.01	66.8	+.3	91	22	79	40	1	55	32	58	54	68	1.64	−2.2	8	6.5	sw.	27	w.	5	11	17	3	4.2	.0	.0
Wytheville	2,304	49	55	27.65	30.02	+.03	61.0	−.4	88	31	73	36	11	49	39	53	48	66	2.70	−1.0	9	6.4	w.	23	w.	22	11	12	8	4.8	.0	.0
South Atlantic States							**70.7**	**+0.6**										**69**	**2.20**	**−1.3**									**3.9**		
Asheville	2,253	89	104	27.70	30.02	+.03	64.3	+1.7	89	31	77	41	7	52	44	55	49	66	2.45	−1.0	14	7.8	nw.	31	nw.	31	10	17	4	4.9	.0	.0
Charlotte	779	63	86	29.18	30.02	+.03	69.8	+.9	93	31	81	43	1	58	28	59	53	59	2.66	−1.0	7	7.0	s.	30	nw.	28	13	14	4	4.2	.0	.0
Greensboro	886	6	56	29.06	30.01	.....	66.4	.....	93	31	80	37	1	53	37	58	53	67	3.06	.....	7	7.6	sw.	28	sw.	12	11	16	4	4.3	.0	.0
Hatteras	11	5	50	30.00	30.01	.00	67.6	−1.1	81	28	73	51	3	62	19	62	59	77	2.36	−1.4	8	12.8	sw.	30	n.	10	18	7	6	3.6	.0	.0
Raleigh	376	103	146	29.60	29.99	.00	69.2	+.7	94	28	81	38	1	58	31	61	56	66	.94	−2.9	2	8.4	sw.	21	w.	5	21	9	1	3.0	.0	.0
Wilmington	72	73	107	29.94	30.02	+.01	69.6	−1.2	89	28	79	45	1	60	27	63	60	76	2.29	−1.2	5	9.1	sw.	27	s.	13	16	14	1	3.5	.0	.0
Charleston	48	11	92	29.97	30.02	+.01	72.6	−.1	90	29	80	55	1	66	22	65	62	74	1.60	−1.4	2	10.0	s.	34	n.	28	14	12	5	4.3	.0	.0
Columbia, S. C	347	70	91	29.64	30.02	+.02	72.7	+.8	95	28	84	50	1	61	30	61	55	62	3.29	+.2	6	8.0	s.	38	sw.	12	20	9	2	2.8	.0	.0
Greenville, S. C	1,039	139					69.4	+2.2	92	29	80	48	1	59	33				3.08	−1.0	8		w.				16	8	7		.0	.0
Augusta	182	62	77	29.80	29.99	.00	73.2	+.8	95	28	84	52	15	62	32	63	57	61	2.31	−.7	7	5.7	nw.	20	n.	28	15	14	2	3.8	.0	.0
Savannah	65	73	152	29.94	30.01	+.01	74.4	+1.0	95	28	84	56	15	65	27	66	62	74	1.97	−1.0	4	9.9	s.	31	n.	28	14	12	5	4.1	.0	.0
Jacksonville	43	86	110	29.96	30.01	+.01	75.4	+.4	93	29	84	61	15	67	25	67	64	74	1.24	−2.8	7	7.3	e.	27	ne.	28	14	12	5	4.4	.0	.0
Florida Peninsula							**77.0**	**+0.2**										**74**	**5.00**	**+0.6**									**3.8**		
Key West	22	10	64	29.93	29.95	−.02	78.8	−.3	88	2	84	70	7	73	17	72	69	75	9.63	+6.1	8	8.9	e.	43	nw.	2	15	11	5	3.8	.0	.0
Miami	25	124	168	29.94	29.97	−.02	77.4	+1.0	86	5	83	66	9	72	17	70	67	72	2.45	−3.8	10	9.0	ne.	22	s.	14	20	7	4	3.5	.0	.0
Tampa	35	88	197	29.94	29.98	−.01	77.2	+.9	94	30	86	64	16	68	22	69	66	75	4.98	+2.0	5	9.7	e.	30	se.	2	16	9	6	4.1	.0	.0
Titusville	43	5	36	29.93	29.98	.....	74.6	−.7	94	29	85	59	12	64	29	68	67	.....	2.95	−1.9	7	.....	e.	.....	.....	.....	15	10	6	.....	.0	.0
East Gulf States							**74.1**	**+1.5**										**69**	**3.45**	**−0.4**									**4.1**		
Atlanta [1]	976	5	53	28.98	29.99	.00	70.9	+1.0	94	31	82	48	15	60	32	61	56	65	2.32	−1.2	9	7.4	nw.	32	sw.	22	10	14	7	5.0	.0	.0
Macon	370	79	87	29.61	30.00	+.01	73.0	+.7	95	29	84	51	15	62	32	63	58	64	2.38	−.6	5	6.1	n.	21	nw.	5	15	12	4	4.0	.0	.0
Thomasville	273	49	58	29.71	29.97	−.02	75.0	+1.0	98	29	86	55	16	64	31	67	63	.....	2.79	−.8	9	.....	e.	.....	.....	.....	.....	.....	.....	.....	.0	.0
Apalachicola	35	11	.....	29.96	30.00	.....	74.6	.0	93	29	82	60	15	67	20	68	66	77	3.43	.0	5	7.8	nw.	42	se.	2	16	10	5	4.0	.0	.0
Pensacola	56	149	185	29.94	30.00	+.01	75.2	+1.3	90	30	80	61	15	70	17	68	66	76	6.46	+3.1	7	10.8	s.	48	se.	2	19	11	1	3.1	.0	.0
Anniston	741	9	.....	.....	.....	.....	70.7	+2.3	96	30	83	44	15	59	33	.....	.....	.....	4.00	+.1	8	.....	w.	.....	.....	.....	14	12	5	.....	.0	.0
Birmingham	700	11	48	29.23	29.99	+.01	72.5	+1.4	94	30	83	48	15	62	31	63	59	68	5.27	+1.3	10	5.8	s.	30	s.	21	14	13	4	4.4	.0	.0
Mobile	57	86	161	29.93	29.99	.00	76.2	+1.8	96	30	85	57	15	67	25	68	65	74	4.62	+.3	8	7.7	s.	29	e.	1	15	12	4	4.2	.0	.0
Montgomery	218	92	105	29.76	30.00	+.01	74.8	+1.4	98	30	85	54	15	64	29	65	61	68	2.87	−1.0	8	6.1	w.	27	n.	31	15	12	4	4.0	.0	.0
Meridian	375	67	92	29.59	29.98	.00	74.4	+3.1	96	31	86	50	15	63	34	65	60	66	2.01	−2.3	9	4.9	sw.	24	n.	31	15	12	4	4.1	.0	.0
Vicksburg	247	65	73	29.73	29.99	+.02	74.9	+2.0	93	31	84	54	15	66	24	66	61	68	1.87	−2.4	6	6.2	sw.	19	e.	1	11	16	4	4.5	.0	.0
New Orleans	53	76	84	29.94	30.00	+.03	77.5	+2.1	92	31	85	63	15	70	20	68	64	67	3.36	−1.2	5	5.7	se.	26	e.	1	14	15	2	4.0	.0	.0
West Gulf States							**74.7**	**+1.4**										**69**	**2.34**	**−1.8**									**4.1**		
Shreveport	249	92	227	29.70	29.96	+.01	76.0	+2.4	93	31	86	54	2	66	27	66	60	65	.98	−3.2	5	10.1	s.	30	nw.	1	14	14	3	4.1	.0	.0
Bentonville	1,303	12	38	28.58	29.93	.00	67.6	+1.2	89	31	78	42	14	57	32	.....	.....	.....	2.75	−2.5	9	5.9	s.	19	w.	21	6	18	7	.....	.0	.0
Fort Smith	457	79	94	29.46	29.94	+.01	71.4	+1.8	92	27	81	50	14	62	30	62	58	67	3.86	−1.0	9	8.0	e.	22	w.	2	10	14	7	5.3	.0	.0
Little Rock	357	94	102	29.59	29.96	+.01	71.9	+1.6	93	31	82	50	4	62	24	63	58	67	2.78	−2.0	9	7.7	sw.	21	nw.	22	10	12	9	5.1	.0	.0
Austin	605	68	90	29.30	29.93	.....	76.4	+1.8	94	22	88	55	5	65	32	65	59	63	3.67	−1.0	4	9.1	s.	23	ne.	3	17	8	6	3.9	.0	.0
Brownsville	57	88	96	29.85	29.91	.....	77.2	−1.4	88	23	84	62	3	70	22	70	68	82	6.83	+4.6	6	11.1	se.	35	n.	13	10	16	5	4.7	.0	.0
Corpus Christi	20	11	78	29.91	29.93	+.03	76.9	+.7	90	1	82	62	15	72	20	71	68	80	1.19	−2.0	4	13.2	se.	30	se.	31	16	9	6	4.1	.0	.0
Dallas	512	220	227	29.40	29.93	.....	74.4	.....	90	25	85	53	2	64	29	63	57	62	.59	−3.9	9	12.2	se.	45	w.	12	12	10	9	4.9	.0	.0
Forth Worth	679	92	110	29.24	29.94	+.03	75.0	+2.7	91	28	86	51	2	64	29	.....	.....	.....	1.00	−3.6	6	10.8	s.	32	sw.	10	16	10	5	3.6	.0	.0
Galveston	54	106	114	29.92	29.98	+.04	76.2	+1.4	84	29	80	65	2	72	17	70	68	79	.10	−3.3	2	11.4	s.	25	se.	29	22	6	3	2.6	.0	.0
Houston	138	292	314	29.83	29.97	.....	76.8	+1.3	91	23	86	57	2	68	24	.....	.....	.....	T	−4.5	0	12.0	se.	25	se.	29	17	11	3	3.5	.0	.0
Palestine	510	64	72	29.44	29.97	+.04	74.4	+1.7	91	30	85	55	14	64	28	64	59	65	.68	−3.9	5	8.0	s.	20	s.	10	10	19	2	4.2	.0	.0
Port Arthur	34	98	106	29.94	29.98	.....	76.0	.....	85	31	82	59	2	70	21	.....	.....	.....	.58	−3.5	2	10.3	s.	38	se.	1	20	10	1	2.9	.0	.0
San Antonio	693	242	301	29.20	29.91	+.01	76.9	+1.8	93	22	88	57	4	66	29	65	59	63	7.68	+4.5	5	12.3	se.	40	se.	30	11	13	7	4.7	.0	.0

[1] Observations taken at airport.

TABLE 2.—*Climatological data for Weather Bureau stations, May 1937*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee	*Ft.*	*Ft*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*		°*F.*	°*F.*		°*F.*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
							65.1	+0.2										66	3.68	−0.1										5.4		
Chattanooga	762	71	214	29.20	30.00	+0.01	70.4	+1.6	95	30	82	49	15	59	33	60	54	62	4.43	+0.6	12	6.9	w.	30	n.	31	13	12	6	4.5	0.0	0.0
Knoxville	995	66	84	28.96	30.00	+.01	68.0	+.8	93	30	79	46	7	57	36	59	53	66	4.38	+.6	9	5.3	ne.	23	nw.	13	12	9	10	4.8	.0	.0
Memphis	399	78	86	29.55	29.96	.00	72.7	+2.1	95	31	81	53	15	64	26	63	58	67	4.04	−.2	13	6.9	sw.	23	sw.	4	7	16	8	5.5	.0	.0
Nashville	546	168	188	29.43	30.02	+.04	68.6	+.4	96	31	78	47	15	59	29	60	55	69	5.33	+1.5	10	7.6	ne.	33	w.	12	7	14	10	5.8	.0	.0
Lexington	989	6	----	----	----	----	64.1	−.2	95	31	75	40	8	52	35	----	----	----	3.28	−.5	14	----	n.	----	----	15	7	9	----	.0	.0
Louisville	525	188	234	29.43	30.01	+.03	65.8	−.8	94	31	76	46	10	57	29	58	53	67	3.84	+.1	9	9.1	n.	33	sw.	22	14	6	11	5.0	.0	.0
Evansville	431	76	116	29.52	29.98	+.01	67.6	+.9	95	31	77	45	10	58	28	59	53	65	5.62	+1.8	10	7.7	s.	34	sw.	22	11	12	8	5.2	.0	.0
Indianapolis	822	194	230	29.12	30.00	+.03	63.0	+.1	92	31	72	39	14	54	29	55	48	64	1.58	−2.3	14	10.0	s.	36	w.	16	9	10	12	5.8	.0	.0
Terre Haute	575	63	149	29.36	29.97	----	65.4	----	94	30	76	42	15	55	29	56	51	65	2.62	−1.2	12	8.8	se.	29	w.	21	12	6	13	5.3	.0	.0
Cincinnati	627	11	51	29.33	30.01	+.02	63.2	+.1	95	31	73	41	6	53	36	56	51	69	2.93	−.8	12	6.5	sw.	27	w.	22	11	5	15	5.9	.0	.0
Columbus	822	90	210	29.13	30.00	+.02	62.5	+.2	92	31	72	40	6	52	29	55	49	65	3.28	−.3	14	8.4	s.	34	w.	22	10	12	9	5.2	.0	.0
Dayton	900	58	153	29.05	29.99	----	62.2	−.4	93	31	71	41	6	53	31	----	----	----	3.66	+.1	12	7.4	sw.	34	w.	21	9	11	11	6.0	.0	.0
Elkins	1,947	59	78	28.00	30.03	+.03	58.4	−.8	87	31	71	32	11	45	42	52	46	70	4.11	+.1	17	5.8	w.	40	nw.	16	4	16	11	6.2	.0	.0
Parkersburg	637	77	84	29.38	30.04	+.05	63.2	−.6	92	31	75	39	11	52	35	56	50	70	3.49	+.1	15	5.6	nw.	26	nw.	16	10	12	9	5.2	.0	.0
Pittsburgh [1]	1,273	39	54	28.65	30.00	+.01	61.4	−1.0	89	31	72	40	20	51	32	52	46	65	2.21	−1.0	13	9.5	nw.	35	nw.	26	7	16	8	5.9	.0	.0
Lower Lake Region							58.3	+0.8										68	2.85	−0.4										5.6		
Buffalo	768	243	280	29.15	29.98	+.01	55.1	+.5	81	30	62	35	10	48	28	50	45	73	3.02	−.1	13	12.5	sw.	45	w.	12	10	10	11	5.5	.0	.0
Canton	448	10	61	29.47	29.94	----	56.6	+.4	84	31	67	33	15	46	33	51	47	72	3.49	+.5	16	8.5	sw.	24	w.	23	7	10	14	6.2	.0	.0
Ithaca	836	77	100	29.07	29.97	----	58.5	+1.0	91	31	70	35	11	46	38	51	46	66	3.50	+.1	16	7.6	nw.	25	s.	12	9	8	12	6.1	.0	.0
Oswego	335	71	85	29.59	29.96	−.01	55.2	.0	85	31	64	39	10	47	32	50	45	71	2.54	−.5	16	7.7	w.	21	n.	15	9	10	12	5.8	.0	.0
Rochester	523	86	102	29.42	29.99	+.02	58.1	+1.0	88	31	68	38	10	49	32	51	45	65	2.37	−.6	13	8.2	w.	27	w.	12	11	8	12	5.4	.0	.0
Syracuse	596	65	79	29.34	29.98	.00	59.4	+1.7	88	31	69	40	10	50	33	----	----	----	3.23	+.2	14	6.9	nw.	21	sw.	17	9	11	11	5.9	.0	.0
Erie	714	130	166	29.22	29.99	+.01	58.2	+1.4	89	31	67	39	10	50	30	51	46	68	2.10	−1.3	15	10.4	w.	30	w.	12	13	9	9	4.8	.0	.0
Cleveland	762	267	318	29.18	30.00	+.02	59.4	+1.5	88	31	68	39	6	51	24	52	46	66	2.27	−.8	13	11.6	s.	53	nw.	22	13	9	9	5.0	.0	.0
Sandusky	629	5	67	29.32	30.00	+.02	60.6	+1.4	93	31	70	42	6	51	31	----	----	----	3.66	+.5	11	7.7	sw.	26	nw.	16	4	16	11	5.9	.0	.0
Toledo	628	70	87	29.33	30.01	+.04	60.0	+.6	92	31	70	37	10	50	29	52	47	66	2.23	−1.3	13	8.4	w.	30	nw.	16	9	15	7	5.1	.0	.0
Fort Wayne	857	69	84	29.08	30.00	----	60.4	+.8	91	31	70	40	15	51	27	53	48	66	2.68	−1.2	14	8.1	nw.	30	w.	16	11	9	11	5.5	.0	.0
Detroit [1]	626	5	78	29.31	30.00	+.03	57.9	−.1	92	31	68	35	10	48	29	52	47	68	3.07	−.1	10	8.4	nw.	29	nw.	17	7	8	16	6.5	.0	.0
Upper Lake Region							54.5	+1.9										68	2.00	−1.2										5.6		
Alpena	609	13	89	29.33	30.00	+.03	53.0	+2.5	93	31	62	34	15	44	33	47	41	68	.90	−2.2	7	10.2	nw.	30	nw.	8	11	9	11	5.1	.0	.0
Escanaba	612	41	49	29.34	30.01	+.04	52.4	+2.8	87	31	62	31	15	42	34	46	39	64	1.38	−1.6	9	8.8	s.	24	n.	13	11	11	9	4.9	.0	.0
Grand Rapids	707	70	244	29.23	30.00	+.03	59.8	+1.8	90	30	70	35	10	50	30	52	46	65	1.86	−1.6	14	9.8	sw.	30	sw.	31	8	13	10	5.7	.0	.0
Lansing	878	5	90	29.05	29.99	----	56.8	−.1	88	31	67	31	15	46	32	52	48	73	3.43	.0	13	7.8	s.	21	nw.	17	8	9	14	6.1	.0	.0
Ludington	637	5	54	29.30	30.00	----	53.2	+1.0	81	30	62	29	10	44	31	48	43	----	1.22	−1.8	7	----	s.	----	----	13	12	6	----	.0	.0
Marquette	734	44	69	29.20	30.00	+.03	51.8	+2.8	92	30	62	30	15	42	43	48	44	78	2.18	−.8	13	8.4	nw.	26	sw.	12	9	12	10	5.4	T	.0
Sault Sainte Marie	614	11	52	29.32	30.02	+.07	51.6	+2.6	89	30	62	28	14	41	37	45	38	65	1.61	−1.4	9	8.1	nw.	26	ne.	5	9	12	10	5.3	.0	.0
Chicago	673	7	131	29.28	30.00	+.04	57.9	+.4	91	31	66	39	15	50	25	51	46	69	1.64	−1.9	11	9.5	ne.	26	n.	5	10	11	10	5.2	.0	.0
Green Bay	617	109	141	29.31	29.97	+.02	56.9	+2.0	90	30	67	32	14	47	30	49	43	62	1.12	−2.4	10	10.9	s.	31	w.	12	6	11	14	6.4	.0	.0
Milwaukee	681	97	221	29.25	29.99	+.03	55.6	+1.5	89	31	64	38	14	47	38	49	43	66	2.70	−.6	15	11.5	n.	34	n.	5	7	14	10	5.7	.0	.0
Duluth	1,133	5	47	28.75	29.98	+.02	51.0	+3.7	81	30	60	29	14	42	36	45	39	71	3.92	+.7	13	11.3	ne.	40	nw.	12	8	12	11	5.7	.0	.0
North Dakota							57.4	+3.4										58	1.63	−0.8										5.4		
Moorhead, Minn	940	50	58	28.93	29.94	.00	58.0	+2.9	89	28	68	33	9	47	31	50	42	62	1.37	−1.5	14	10.0	s.	24	e.	17	8	12	14	6.7	.0	.0
Bismarck	1,674	8	57	28.16	29.92	.00	58.9	+4.4	94	28	71	28	13	47	40	49	39	55	1.52	−.8	8	11.1	nw.	31	nw.	12	9	14	8	5.1	.0	.0
Devils Lake	1,478	11	44	28.38	29.95	+.01	55.6	+3.0	93	28	67	24	13	44	37	48	42	67	1.41	−.6	9	10.8	se.	27	n.	12	7	12	10	5.8	.0	.0
Grand Forks	833	12	67	----	----	----	56.5	+2.8	89	28	68	28	13	45	34	50	----	----	3.33	+.7	9	----	se.	35	nw.	12	7	14	10	----	.0	.0
Williston	1,878	42	50	27.96	29.93	.00	57.8	+3.8	92	28	70	29	8	45	41	47	35	49	.50	−1.6	7	10.3	se.	34	nw.	12	15	13	3	3.9	.0	.0
Upper Mississippi Valley							63.1	+1.5										67	3.84	−0.2										5.6		
Mpls.-St. P., Minn	919	105	208	28.98	29.96	+.02	59.8	+2.1	90	29	70	36	14	50	29	52	44	60	5.42	+1.8	12	11.5	s.	31	nw.	16	6	12	13	6.0	.0	.0
La Crosse	714	11	48	29.19	29.96	+.02	60.8	+1.5	89	30	71	36	14	51	30	53	47	67	2.98	−.8	9	6.0	s.	20	nw.	16	12	9	10	5.0	.0	.0
Madison	974	70	78	28.94	29.98	+.02	58.6	+1.0	89	30	68	36	14	49	26	52	46	66	1.49	−2.4	10	7.7	s.	26	s.	11	5	14	12	6.3	.0	.0
Charles City	1,015	10	51	28.89	29.99	+.05	59.8	+2.0	88	30	70	34	14	50	32	54	49	70	4.83	+.5	9	7.2	se.	25	se.	29	14	7	10	4.6	.0	.0
Davenport	606	66	161	29.32	29.98	+.03	63.6	+2.3	91	31	73	44	7	54	26	56	50	68	3.91	.0	12	9.8	ne.	32	n.	18	7	10	14	6.0	.0	.0
Des Moines	861	5	99	29.05	29.95	+.02	63.4	+2.1	88	29	73	43	14	54	30	56	52	70	7.13	+2.6	10	9.5	se.	32	nw.	26	9	10	12	5.7	.0	.0
Dubuque	699	60	79	29.23	29.98	+.03	61.2	+.9	88	30	70	43	14	52	28	54	49	67	4.21	.0	15	6.1	s.	18	nw.	16	10	8	13	5.9	.0	.0
Keokuk	614	64	78	29.32	29.96	+.02	64.6	+.8	90	29	74	43	15	55	28	57	52	67	2.85	−1.1	9	7.6	s.	22	s.	11	10	8	13	6.1	.0	.0
Cairo	358	87	93	29.59	29.97	+.01	69.4	+1.0	94	30	78	50	14	61	28	61	56	67	4.92	+1.2	9	7.7	n.	51	n.	18	5	16	10	6.0	.0	.0
Peoria	609	11	45	29.33	29.99	+.03	63.2	+1.5	92	30	73	42	10	53	29	56	52	70	3.22	−.8	14	6.5	s.	20	sw.	25	14	12	5	4.2	.0	.0
Springfield, Ill	636	5	191	29.30	29.97	+.02	65.4	+2.2	93	30	75	45	15	55	27	57	53	70	2.42	−2.0	9	11.1	s.	27	s.	3	7	11	13	5.8	.0	.0
St. Louis	568	179	303	29.36	29.96	+.01	67.2	+.2	93	30	76	47	15	59	31	59	54	66	2.65	−1.7	10	11.4	s.	43	sw.	21	10	14	7	5.3	.0	.0
Missouri Valley							64.5	+2.9										67	3.67	−1.1										5.5		
Columbia, Mo	784	6	64	29.12	29.94	.00	66.4	+2.1	91	29	76	46	15	57	29	----	----	----	4.67	+.2	10	7.4	s.	22	nw.	12	8	15	8	5.6	.0	.0
Kansas City [1]	750	32	45	29.14	29.94	+.02	67.2	+2.4	90	28	77	44	14	58	31	59	55	69	3.63	−1.0	12	8.6	sw.	30	se.	21	8	10	13	5.9	.0	.0
St. Joseph	967	11	49	28.92	29.94	----	66.2	----	91	28	76	40	14	56	29	59	54	71	3.93	−.8	13	8.0	s.	30	w.	11	14	7	10	5.0	.0	.0
Springfield, Mo	1,324	98	104	28.57	29.96	+.03	65.8	+1.3	87	20	74	44	14	57	26	59	55	71	5.09	−.1	10	8.9	s.	27	ne.	21	9	18	6	4.6	.0	.0
Topeka	987	65	87	28.90	29.92	----	67.8	+3.5	92	28	79	41	14	57	32	59	55	70	3.12	−1.4	14	8.9	s.	28	n.	12	10	11	10	5.4	.0	.0
Lincoln	1,189	11	81	28.67	29.91	.00	64.5	+2.8	94	28	76	37	14	53	36	56	50	65	1.89	−2.2	12	9.8	s.	27	n.	4	7	13	11	5.8	.0	.0
Omaha [1]	982	31	44	28.89	29.93	+.01	64.2	+1.8	89	28	75	37	14	53	33	56	51	69	2.45	−1.3	11	11.6	s.	34	nw.	11	8	13	10	5.6	.0	.0
Valentine	2,598	47	54	27.25	29.94	+.04	60.5	+4.3	94	28	72	38	13	49	38	51	43	60	1.72	−1.1	11	10.8	s.	32	nw.	12	10	9	12	5.8	.0	.0
Sioux City	1,138	64	106	28.72	29.92	.00	63.9	+3.5	89	20	74	39	14	53	32	54	48	63	2.70	−1.4	15	10.3	s.	31	nw.	11	8	10	12	6.1	.0	.0
Huron	1,307	59	74	28.54	29.93	+.01	60.6	+4.2	90	29	72	37	13	49	36	52	45	64	1.48	−1.5	10	10.9	se.	37	w.	12	9	15	7	5.3	.0	.0
Northern Slope							56.1	+3.6										53	1.23	−1.1										5.5		
Havre	2,507	11	67	27.32	29.93	+.03	57.6	+4.2	86	22	72	33	16	44	40	44	30	44	.51	−1.5	7	10.4	w.	37	n.	28	12	11	8	4.7	.0	.0
Helena	4,124	85	111	25.79	29.95	+.02	54.7	+3.1	81	22	67	34	16	42	40	45	36	54	.29	−2.0	4	9.7	sw.	36	w.	28	9	9	13	6.0	.0	.0
Missoula	3,263	80	91	----	----	----	56.4	+3.6	83	4	70	32	6	43	44	----	----	----	.97	−1.0	7	8.5	nw.	32	sw.	16	9	8	14	5.5	.0	.0
Kalispell	2,973	48	56	26.92	29.96	+.08	53.2	+1.8	80	25	66	30	6	40	39	43	32	50	1.00	−.5	10	7.4	w.	24	s.	28	10	8	13	5.1	.0	.0
Miles City	2,371	48	55	27.43	29.96	+.05	60.4	+3.7	94	28	72	37	9	48	42	48	36	46	.81	−1.4	8	8.6	se.	41	nw.	28	8	15	8	5.5	.0	.0
Rapid City	3,259	50	58	26.60	29.98	+.08	58.0	+4.0	92	28	69	38	9	47	36	49	40	56	2.80	−.8	13	9.6	n.	32	nw.	12	11	11	9	5.2	.0	.0
Cheyenne [1]	6,144	5	39	23.95	29.91	+.06	52.8	+2.5	82	17	67	28	13	39	40	43	34	60	1.19	−1.2	8	12.7	n.	37	w.	11	7	11	13	6.2	.2	.0
Lander	5,372	60	68	24.63	29.92	+.04	55.3	+4.1	84	18	70	30	1	41	46	43	30	47	2.23	.0	7	6.2	sw.	32	sw.	18	10	10	11	5.7	.0	.0
Sheridan	3,790	10	47	26.07	29.93	----	57.0	----	91	28	71	31	13	43	45	47	37	53	2.39	−.3	10	7.4	nw.	30	e.	18	10	11	10	5.5	.0	.0
Yellowstone Park	6,241	12	46	23.87	29.97	+.06	49.4	+4.8	74	18	63	28	1	36	39	39	30	55	.75	−1.0	7	8.4	sw.	32	sw.	28	8	16	7	5.3	T	.0
North Platte	2,821	11	51	27.02	29.92	+.04	62.8	+4.1	92	28	78	38	1	51	38	52	46	63	.64	−2.1	9	9.2	s.	24	n.	12	8	9	14	6.0	.0	.0

[1] Observations taken at airport.

TABLE 2.—*Climatological data for Weather Bureau stations, May 1937*—Continued

District and station	Elevation of instruments: Barometer above sea level	Thermometer above ground	Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Departure from normal	Days with 0.01 inch or more	Wind: Average hourly velocity	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*		°*F.*	°*F.*		°*F.*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Middle Slope							65.6	+3.1										59	1.93	−1.4										5.7		
Denver	5,292	106	113	24.72	29.91	+0.07	59.0	+2.8	84	19	71	36	4	47	38	46	35	49	1.46	−.8	7	8.2	s.	30	nw.	30	7	10	14	6.3	0.0	0.0
Pueblo	4,685	80	86	25.26	29.88	+.05	62.8	+3.6	89	14	77	38	2	49	45	48	45	49	.70	−.9	7	7.6	nw.	30	sw.	25	7	14	10	5.6	.0	.0
Concordia	1,392	50	58	28.46	29.92	+.01	65.9	+2.7	92	28	77	37	14	54	38	57	51	66	1.85	−2.3	12	8.9	s.	23	s.	30	6	18	7	5.5	.0	.0
Dodge City	2,509	10	86	27.35	29.91	+.04	67.0	+3.5	96	20	80	42	5	54	39	55	48	59	1.64	−1.2	10	13.3	s.	35	n.	21	8	19	4	5.1	.0	.0
Wichita	1,358	85	93	28.50	29.91	+.01	67.6	+2.5	93	19	78	45	14	58	27	59	54	66	4.13	−.3	11	11.0	se.	30	ne.	16	5	18	8	6.0	.0	.0
Oklahoma City	1,214	10	47	28.65	29.90	+.01	71.2	+3.5	92	19	82	49	5	61	27	61	56	64	1.82	−3.1	11	10.1	s.	27	sw.	21	9	12	10	5.5	.0	.0
Southern Slope							72.4	+1.8										53	3.28	+0.6										4.6		
Abilene	1,738	10	52	28.12	29.88	+.01	74.8	+2.8	95	15	87	51	5	63	33	62	53	54	2.14	−1.8	9	11.1	s.	34	sw.	25	11	13	7	4.6	.0	.0
Amarillo	3,676	10	49	26.22	29.89	+.05	67.4	+3.3	93	20	79	44	1	56	36	55	45	54	6.83	+4.0	13	10.2	se.	32	sw.	18	12	11	8	5.0	.0	.0
Del Rio	960	63	71	28.86	29.83	+.02	78.2	+1.2	97	8	89	59	2	68	33	66	59	59	.26	−2.6	4	11.6	se.	30	se.	28	10	10	11	5.1	.0	.0
Roswell	3,566	75	85	26.30	29.84	+.02	69.2	−.2	98	15	83	41	1	56	40	54	40	46	3.88	+2.8	8	8.4	s.	29	sw.	6	18	9	4	3.7	.0	.0
Southern Plateau							67.9	+2.9										38	1.05	+0.5										2.8		
El Paso	3,778	82	101	26.10	29.78	.00	74.4	+2.9	98	16	88	44	1	61	41	54	36	32	.19	−.1	3	8.4	e.	29	nw.	28	20	10	1	2.3	.0	.0
Albuquerque [1]	4,972	5	39	25.00	29.80	.....	64.5	+1.2	92	17	80	36	1	49	42	42	32	42	2.78	+2.2	7	9.7	se.	52	w.	18	17	8	6	3.5	.0	.0
Santa Fe	7,013	38	53	23.24	29.85	+.04	58.8	+3.1	81	17	71	35	4	47	32	45	34	48	3.97	+2.7	7	6.7	se.	20	s.	19	12	11	8	4.8	.0	.0
Flagstaff	6,907	10	59	23.32	29.78	.00	53.5	+2.8	81	15	71	24	1	36	45	41	.....	42	.31	−.9	2	9.1	sw.	32	s.	30	6	19	6	.....	.0	.0
Phoenix	1,107	39	51	28.62	29.75	−.03	78.6	+3.6	107	15	95	52	1	62	43	57	39	29	.08	.0	1	6.7	w.	22	w.	26	21	7	3	2.5	.0	.0
Yuma	141	9	54	29.62	29.76	−.03	78.1	+1.9	110	14	95	52	8	61	45	59	42	36	T	.0	0	5.4	sw.	20	nw.	25	26	5	0	1.1	.0	.0
Independence	3,957	5	26	25.88	29.85	+.01	67.5	+4.5	96	14	85	40	1	50	46	48	28	.....	.04	−.1	1	.....	nw	.....	.....	.....	24	2	5	.....	.0	.0
Middle Plateau							60.4	+4.8										39	0.50	−0.3										4.2		
Reno	4,527	61	76	25.42	29.90	−.01	59.2	+5.0	86	23	75	34	8	44	38	45	32	42	.02	−.6	1	7.4	w.	29	nw.	25	19	9	3	3.1	.0	.0
Tonopah	6,090	12	20	.....	.....	.....	60.5	.....	84	13	72	31	30	49	32	44	27	34	.24	.....	3	.....	nw.	.....	.....	.....	.....	.....	.....	.....	.....	.....
Winnemucca	4,344	18	56	25.56	29.90	−.01	58.2	+4.3	88	13	76	32	30	41	47	44	30	44	1.03	+.2	4	8.2	ne.	28	n.	29	15	10	6	3.9	2.0	.0
Modena	5,473	10	43	24.54	29.80	−.02	58.2	+4.7	87	14	76	28	1	40	48	43	26	36	.64	−.2	4	10.3	sw.	41	sw.	18	13	10	8	4.2	T	.0
Salt Lake City [1]	4,227	32	46	25.65	29.84	−.02	61.6	.....	88	22	76	32	1	47	43	48	36	43	1.05	.....	5	9.2	se.	42	s.	18	12	9	10	5.1	.0	.0
Grand Junction	4,602	60	68	25.29	29.82	−.01	66.2	+5.1	91	17	80	38	1	52	37	49	34	37	.30	−.5	3	7.9	se.	33	nw.	14	9	16	6	4.9	.0	.0
Northern Plateau							58.6	+2.5										44	0.36	−1.0										4.8		
Baker	3,471	48	53	26.43	30.00	+.04	54.6	+2.9	83	13	70	29	46	39	47	43	32	49	.01	−1.5	1	7.8	n.	28	n.	30	14	7	10	4.6	.0	.0
Boise	2,739	79	87	27.11	29.94	.00	60.4	+3.3	87	13	74	37	5	47	41	48	36	47	.37	−1.1	4	6.4	nw.	22	sw.	18	14	11	6	4.1	.0	.0
Pocatello	4,477	60	68	25.42	29.89	.00	58.0	+4.2	82	28	71	33	30	45	39	45	32	42	1.05	−.5	4	9.3	w.	37	sw.	18	14	11	6	4.2	.5	.0
Spokane	1,929	101	110	27.94	29.97	+.01	57.3	+1.8	83	3	70	35	6	45	38	46	33	45	.23	−1.2	4	7.9	s.	24	sw.	22	14	11	6	4.1	.0	.0
Walla Walla	991	57	65	28.91	29.98	+.02	61.0	+1.4	90	3	73	40	6	49	37	49	36	44	.47	−1.1	4	6.7	sw.	29	w.	16	16	9	6	3.9	.0	.0
Yakima	1,076	58	67	28.84	29.99	.....	60.2	+1.2	88	2	73	36	11	47	38	47	33	40	T	−.6	0	8.0	nw.	27	s.	7	19	8	4	3.6	.0	.0
North Pacific Coast Region							54.9	+1.4										72	1.94	−0.7										6.4		
North Head	211	11	56	29.86	30.09	+.06	50.9	.0	73	6	55	43	2	47	23	48	46	86	1.58	−1.4	10	17.7	nw.	65	se.	7	5	7	19	7.5	.0	.0
Seattle	125	90	321	29.92	30.05	+.04	56.7	+2.2	81	2	65	43	5	48	32	49	43	64	1.57	−.3	14	9.4	n.	31	sw.	16	7	12	12	6.0	0	0
Tatoosh Island	86	10	54	29.97	30.07	+.06	50.7	+1.1	67	6	54	43	5	47	20	47	44	80	3.73	−.3	10	13.8	w.	43	e.	6	5	10	16	6.9	.0	.0
Medford [1]	1,329	29	58	28.60	30.00	.....	57.8	.....	87	31	74	35	5	44	45	49	41	61	1.63	+.4	7	.....	w.	.....	.....	.....	12	9	10	5.0	.0	.0
Portland, Oreg.	153	68	106	29.89	30.05	+.02	58.4	+1.5	84	2	68	39	5	48	36	51	43	62	1.06	−1.1	9	7.2	nw.	22	s.	7	10	7	14	5.7	.0	.0
Roseburg	510	45	76	29.49	30.04	+.01	58.0	+2.0	86	2	70	39	6	46	45	50	44	67	1.74	−.2	10	5.3	n.	28	s.	7	8	9	14	5.9	.0	.0
Middle Pacific Coast Region							61.3	+1.7										61	0.27	−1.0										3.8		
Eureka	62	73	89	30.02	30.09	+.04	52.2	+.2	60	8	57	42	1	48	15	49	46	81	.88	−.9	11	9.2	n.	32	n.	4	9	9	13	5.5	.0	.0
Redding [1]	722	20	34	.....	.....	.....	69.2	+2.8	95	27	82	45	10	57	36	53	37	37	.12	−1.4	2	9.6	nw.	27	sw.	24	15	8	8	4.1	.0	.0
Sacramento	66	92	115	29.83	29.90	−.04	66.7	+3.4	94	27	81	45	8	52	38	54	44	52	.01	−.8	1	7.9	s.	29	nw.	29	22	9	0	2.1	.0	.0
San Francisco	155	112	132	29.79	29.96	−.03	57.2	+.4	77	2	64	48	21	50	26	51	47	75	.06	−.7	2	10.3	w.	27	w.	15	16	12	3	3.7	.0	.0
South Pacific Coast Region							65.6	+2.2										64	0.20	−0.2										5.2		
Fresno	327	97	105	29.53	29.88	−.04	70.6	+3.5	99	13	85	47	8	56	39	56	43	44	.00	−.4	0	7.5	nw.	20	nw.	9	19	9	3	3.2	.0	.0
Los Angeles	338	159	191	29.55	29.92	−.03	64.0	+1.8	86	12	71	51	4	57	28	57	52	71	.28	−.2	5	5.4	sw.	15	sw.	26	10	10	11	5.8	.0	.0
San Diego	87	62	70	29.82	29.91	−.04	62.1	+1.3	78	13	67	54	26	57	20	57	54	78	.32	.0	4	6.8	sw.	17	nw.	1	6	12	13	6.6	.0	.0
West Indies																																
San Juan, P. R.	82	9	54	29.87	29.95	.....	80.8	+2.2	92	24	86	73	14	75	17	.....	.....	.....	1.50	−3.7	10	9.0	se.	26	e.	7	4	22	5	5.2	.0	.0
Panama Canal																																
Balboa Heights	118	6	92	.....	[3] 29.83	+.01	80.6	−.1	93	5	86	72	8	75	17	.....	.....	[3] 88	10.98	+3.0	22	5.4	nw.	24	s.	7	0	17	14	7.4	.0	.0
Cristobal	36	6	97	.....	[3] 29.84	.00	81.9	+1.2	90	27	87	75	26	77	15	76	75	[3] 81	20.99	+8.3	24	7.1	n.	28	w.	26	1	11	19	7.7	.0	.0
Alaska																																
Fairbanks	454	11	87	.....	[3] 29.80	.....	43.6	−3.4	67	31	54	4	1	32	32	.....	.....	58	.38	−.2	5	6.1	ne.	30	se.	28	8	10	13	.....	1.0	.0
Juneau	80	96	116	[3] 29.86	[3] 29.94	.....	47.0	−.8	64	7	53	34	2	41	23	42	37	72	5.82	+.7	23	7.0	s.	24	se.	11	0	2	29	9.2	.0	.0
Nome	22	5	32	[3] 29.79	[3] 29.81	.....	31.2	−3.1	51	28	39	4	13	24	25	29	23	68	.86	+.2	8	7.1	ne.	28	n.	25	6	17	8	5.6	11.0	T
Hawaiian Islands																																
Honolulu	38	86	100	[3] 30.02	[3] 30.06	.....	74.4	−.4	82	11	78	67	11	70	15	68	64	71	1.54	−.2	18	9.6	e.	26	e.	6	9	15	7	5.1	.0	.0

[1] Observations taken at airport.
[3] Observations taken bihourly.
[4] Pressure not reduced to a mean of 24 hours.

TABLE 3.—*Data furnished by the Canadian Meteorological Service, May 1937*

Station	Altitude above mean sea level Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max.+ mean min.÷2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*In.*	*In.*	*In.*
Cape Race, Newfoundland	99				40.6		47.1	34.2	62	21	2.55		0.0
Sydney, Cape Breton Island	48	29.93	29.98	+0.01	49.7	+4.5	59.7	39.8	83	25	3.04	−0.73	.0
Halifax, Nova Scotia	88	29.72	29.82	−.16	50.7	+2.3	58.8	42.7	83	32	4.49	+.23	.0
Yarmouth, Nova Scotia	65	29.84	29.91	−.07	51.6	+4.0	60.1	43.0	71	32	5.90	+2.33	.0
Charlottetown, Prince Edward Island	38	29.89	29.93	−.03	51.6	+4.7	60.7	42.6	82	32	3.74	+.83	.0
Chatham, New Brunswick	28	29.86	29.89	−.06	51.5	+3.0	62.9	40.1	92	25	3.55	+.34	T
Father Point, Quebec	20	29.89	29.91	−.02	47.2	+3.2	55.0	39.4	72	33	2.22	−.36	.0
Quebec, Quebec	296	29.57	29.89	−.05	55.4	+5.5	64.6	46.2	86	34	4.54	+1.46	.0
Doucet, Quebec	1,236				49.7		63.7	35.7	86	17	2.05		.0
Montreal, Quebec	187												
Ottawa, Ontario	236	29.67	29.93	−.01	56.3	+1.4	67.7	45.0	89	31	2.22	−.37	.0
Kingston, Ontario	285	29.64	29.95	−.01	54.0	+1.1	61.5	46.5	75	38	2.74	+.06	.0
Toronto, Ontario	379	29.56	29.96	−.02	56.5	+3.3	65.3	47.7	84	38	2.90	−.14	.0
Cochrane, Ontario	930				49.8		61.9	37.7	90	21	1.84		2.8
White River, Ontario	1,244	28.76	30.08	+.13	48.8	+3.1	63.5	34.1	86	16	2.68	+.73	.3
London, Ontario	808				54.5		64.7	44.3	85	32	2.18		.0
Southampton, Ontario	656	29.28	30.00	+.04	51.7	+1.0	60.9	42.4	88	31	1.41	−1.03	.0
Parry Sound, Ontario	688	29.27	29.97	+.02	53.8	+2.7	64.6	42.9	86	33	2.39	−.54	.0
Port Arthur, Ontario	644	29.38	30.10	+.14	47.2	+1.3	57.8	36.7	86	20	3.93	+1.78	.0
Winnipeg, Manitoba	760	29.11	29.94	−.02	55.2	+3.6	66.5	43.9	87	24	2.20	−.08	.0
Minnedosa, Manitoba	1,690	28.14	29.94	−.02	53.4	+5.0	66.1	40.7	82	19	2.76	+1.31	.0
Le Pas, Manitoba	860				53.8		66.0	41.6	76	25	1.79		.0
Qu'Appelle, Saskatchewan	2,115	27.67	29.90	−.04	52.9	+3.1	66.5	39.2	83	14	.94	−.71	.0
Moose Jaw, Saskatchewan	1,759				55.0		69.0	41.0	83	20	1.40		.0
Swift Current, Saskatchewan	2,392	27.39	29.88	−.04	54.9	+4.2	68.9	40.9	82	28	.93	−.83	.6
Medicine Hat, Alberta	2,365	27.44	29.91	+.02	56.5	+2.4	68.6	44.5	80	27	2.08	+.77	.0
Calgary, Alberta	3,540												
Banff, Alberta	4,521												
Prince Albert, Saskatchewan	1,450	28.39	29.97	+.02	54.0	+6.4	67.1	41.0	79	22	2.44	+1.18	.0
Battleford, Saskatchewan	1,592	28.20	29.93	+.01	52.7	+1.7	68.1	37.4	85	20	1.41	−.21	.0
Edmonton, Alberta	2,150	27.72	29.99	+.11	53.6	+2.8	66.0	41.1	79	30	1.69	+.14	.0
Kamloops, British Columbia	1,262	28.69	29.97	+.08	56.6	−2.5	69.3	43.8	87	32	.56	−.68	.0
Victoria, British Columbia	230	29.80	30.06	+.06	53.4	+.9	60.6	46.2	71	42	.43	−1.05	.0
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20				49.3		54.8	43.7	60	35	10.62		.0
Prince Rupert, British Columbia	170				48.4		56.5	40.3	71	33	5.19		.0
St. George's, Bermuda	158		30.05		69.9	+.8	74.8	65.0	81	58	7.15	+2.95	.0
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Cape Race, Newfoundland	99				32.1		36.1	28.1	43	20	3.06		18.2
Estevan Point, British Columbia	20				44.9		49.6	40.3	56	34	22.24		.0

TABLE 4.—*Severe local storms, May 1937*

[Compiled by Mary O. Souder from reports by Weather Bureau officials]

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the United States Meteorological Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Avoyelles and Pointe Coupee Parishes, La., and vicinities.	Apr. 30–May 1.			5		Tornado and hail	75 persons homeless; large loss in cotton and vegetable crops, $160,000 loss at the Angola Penal farm alone. Small buildings demolished; trees uprooted.
Abbeville, La	1	3–3:40 a. m.			$5,000	Hail and wind	Storm general over Vermilion Parish.
Houma, La	1	6:20 a. m.				do	All gardens damaged; considerable loss to bean and corn crops; power lines crippled; fences down.
Falfurrias, Tex	1	6:45 p. m.		1	50,000	Tornado	2 persons injured, 1 fatally; damage mostly to crops; 2 mules killed. Thunder and hail accompanied this storm.
Valley Springs, S. Dak., vicinity of.	2	2 p. m.		0	1,000	do	Several small buildings wrecked.
Melville, La	4	6:30 p. m.			15,000	Wind and hail	Much loss to cotton, corn, truck, and fruit. Smokestack blown down, sheds unroofed and roofs damaged.
Swainsboro, Ga.[3] vicinity of	5		[1] 2–4	0		Tornado and hail	Much crop loss; trees damaged.
Wayne County, Ga	5					Hail	Loss in thousands of dollars to property and tobacco crop.
Baltimore, Md	6		33	0	500	Small tornado	Storm of short duration and little damage occurred in the northeast section of the city. Large sections of tar paper and tin roofing blown off, some of it carried blocks away. Path 333 yards long.
Meade, Kans., and vicinity	7	7 p. m.	[1] 5		1,000	Hail	Loss to wheat and gardens; path 8 miles long.
Lyon County, Iowa	11	4 p. m.		0	1,800	Tornado and hail	Barns and outbuildings wrecked; path narrow.
Kingman and Harper Counties,	11	5:30 p. m.	440–880	0	2,000	5 tornadoes	Only 2 tornadoes destructive. Each tornado distinct in time and path. Paths 5 to 15 miles long.
McClain County, Okla	11	6 p. m.	880		2,400	Heavy hail	Crop loss $900; damage principally to houses and terraces, $1,500.
Winnebago County, Iowa	11	6:30 p. m.		0	3,000	Tornado	Property damaged. No details.
Southern Nicollet and Le Sueur Counties, Minn.	11	do	100	0	40,000	do	Large barn and several outbuildings, sheds, and garages wrecked; poles and wires down; trees uprooted; some livestock killed. Path 30 miles long.

See footnotes at end of table.

TABLE 4.—*Severe local storms, May 1937*—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Wright, Cerro Gordo, Floyd, and Mitchell Counties, Iowa.	11	7-9 p. m.		0	$60,000	Tornado and hail.	Many farm buildings demolished. Man trapped in his barn and injured as it collapsed. Livestock killed; trees uprooted.
Hastings, Minn., vicinity of	11	7:30 p. m.			1,800	Wind	Damage to telephone lines.
Warren County, Iowa	11	9 p. m.			2,000	do	Buildings damaged.
Roland, Iowa	11	9:30 p. m.		0	2,500	Tornado	Grandstand and several homes damaged; trees uprooted; barn wrecked; and automobile carried across an open field. One person injured.
Promeroy, Iowa, vicinity of	11	P. m.		1		Electrical	Barn destroyed.
Prescott and Martell, Wis.	11		880		10,000	Wind	Property damaged; path 15 miles long.
Garvin County, Okla., south portion.	12	5 p. m.	[1] 3-6		12,000	Heavy hail	The principal amount of loss to crops; path 15 miles long.
Saline County, Ark., southeastern portion.	12	P. m.			2,000	Electrical	House, barn, and contents destroyed.
Frederick County, Md.	13	4:30 p. m.	[1] 2	0	10,000	Tornado	Homes and barns unroofed or otherwise damaged; number of barns and sheds demolished; trees uprooted and electric poles broken. Path 5 miles long.
Westminster, Md., vicinity of	13	5:30 p. m.	0		155,000	do	Many barns, silos, garages, and outbuildings destroyed; bridges twisted; many trees uprooted and tops of many shade trees blown off; poles and wires down; path 8 miles long.
Greenwich, Conn.	17	4 p. m.	50-100	0		do	Storm struck in the Bruce Park section only. Several large trees uprooted and small trees snapped off at the base.
Day and Codington Counties, S. Dak.	17	9—9:15 p. m.	[1] 1	0	100,000	do	Buildings and telephone lines damaged; windows broken. In the vicinity of Roslyn and Greenville, 20 barns were demolished.
Yellow Medicine, Lyon, and Murray Counties, Minn.	17	10:30—11:55 p.m.	[1] 12	0	150,000	Tornado and hail.	Many barns, outbuildings, silos, windmills, and garages wrecked; residences town buildings and farm machinery damaged; many poles and wires down; trees uprooted; growing crops damaged. 3 persons injured. Loss in livestock and poultry; path 63 miles long.
Wayne County, Iowa	18	1 a. m.		0	15,000	Thundersquall, hail, and tornado.	Severe thundersquall over much of county. Heavy hail damaged crops and gardens in an area 6 miles square; many buildings wrecked. Report of funnel cloud and much freakish damage in Washington Township. 2 inches of rain that fell in 30 minutes caused flooding.
Spirit Lake, Roland, Iowa, and vicinity.	18	1:45—4 a. m.	[1] 1	0	75,000	Tornado and hail.	Much farm property damaged or destroyed; 2 persons seriously injured.
Hancock County, Iowa	18	3 a.m.			2,500	Wind	No details.
Black Hawk, Linn, Jones, and Cedar Counties, Iowa.	18	4-5 a. m.		0	20,000	Tornado	Buildings unroofed or wrecked; trees uprooted; telephone service interrupted: man injured; path narrow.
Linton, Ind.	18	2:10 p. m.			3,000	Hail	Damage to automobiles, windows, and gardens.
Alexander and Pulaski Counties, Ill.	18					Rain, hail, and wind.	Property damaged; loss to fruit and berry crops. In Cairo, hundreds of window panes broken and many roofs damaged. Telephone lines broken by falleng trees. Failure of power supply prevented operation of city pumps; sewers inadequate; streets flooded. Accurate estimate of this storm not now available.
Cotton Hill, Ill.	18				500	Hail	Property damaged; some loss to wheat crop.
Springfield, Ill.	18				1,000	do	Damage to greenhouses and roofs.
Calhoun, Ky.	18				5,000	Wind	Damage to buildings and trees.
Henderson, Ky.	18				25,000	Wind and hail.	Damage to buildings, electric lines, and trees. Loss to young fruits in orchards east of the city.
Louisville, Ky., south portion.	18				500	Hail	Gardens and greenhouses damaged.
Snow Hill, Md., and vicinity.	19	2 a. m.	[1] 1-2		2,000	Thundersquall	A building and garage unroofed; several telephone poles broken off and barn demolished.
Floyd County, Ind.	19	4 p. m.			50,000	Hail	Loss to crops.
Glen Elder and Beloit, Kans.	19	do	[1] 4		13,000	Wind	Damage to farm residences, barns, and outbuildings; path 12 miles long.
Phillipsburg, Kans., and vicinity.	19	9:07 p. m.	440	0	10,000	Tornado	Chief damage to a lumberyard and small buildings; some damage to wire service. Path 1½ miles long.
South Dakota, east portion.	20	4:30-6 p. m.		1	65,000	Thundersquall and hail.	Roofs torn off; windows broken, a pavilion and several barns wrecked. Man killed by lightning and several persons injured by flying missiles.
Cass County, Iowa	20	5 p. m.			500	Wind, rain, and hail.	Property damaged; crop loss.
Pottawattamie County, Iowa	20	6 p.m.			6,000	Wind and hail	$1,000 damage to buildings by wind; crop loss, $5,000.
Stevens, Pope, Big Stone, Swift, Lac Qui Parle, and Chippewa Counties, Minn.	20	8-10 p. m.			90,000	Thunderstorm and hail.	A number of barns, small outbuildings, silos, and windmills wrecked. Hail caused loss to growing crops over a wide area. Some rye and flax fields damaged 30 to 40 percent.
Union City, Iowa	20	8:30 p. m.			800	Wind	Buildings damaged.
Monroe County, Iowa	20	9:30 p. m.			500	Tornadic winds	Several buildings damaged.
Osceola, Iowa	20	10 p. m.	400	0		Tornado	Trees uprooted; other damage slight; path 1,320 yards long.
Salem, Ill., vicinity of	21					Hail	Considerable property damage; loss to crops.
Alfalfa County, Okla.	21		[1] 2½		270,000	Heavy hail	Crop loss severe and estimated at $250,000; other damage $20,000.
Wakita, Okla., vicinity of	21		1,320		30,000	Hail	Loss to crops; path 8 miles long.
Stafford, Kans., vicinity of	21	1 a. m.	[1] 3		15,000	Heavy hail	Chief loss to wheat crop; path 15 miles long.
Capron, Okla., vicinity of	21	5 p. m.			1,500	Hail	Property damaged; no material crop loss.
Sedgwick, Sumner, Cowley, Harvey, and McPherson Counties, Kans.	21	5-6 p. m.	[1] 18		615,500	Heavy hail	In Belle Haven and vicinity, several houses and high school building badly damaged. Many wheat fields total loss. In north portions of Sedgwick and Harvey Counties, damage mostly to crops. In Windom many windows broken. Path 30 miles long.
Welda and Mt. Ida, Kans.	21	5:30 p. m.	880		3,000	do	Chief damage to crops; path 1½ miles long.
Earlton, Chanute and Urbana, Kans.	21	8 p. m.	33	0	3,000	Tornado	Property damaged; path 6 miles long.
Lawton, Okla.	22	1 a. m.	880			Hail	Only slight damage to property; loss to crops from 10 to 100 percent.
Cambridge, Md., vicinity of	22	5 p. m.	200-1,000	0	5,025	Tornado	8 small buildings on a farm demolished; trees uprooted and loss to crops.
Huntingtown, Md., vicinity of	22		67		2,075	Wind	New tobacco barn and an old garage demolished; another barn damaged and trees uprooted. Path 133 yards long.
Buffalo, N. Y.	22					Thundersquall	Streets and cellars flooded; electric and telephone service interrupted. Some street blocked by falling trees and wires. Number of motor accidents reported.
Lockport, N. Y., and vicinity	22					do	Considerable damage reported.
Nelson County, Va.	22				1,000	Thunderstormand hail.	Gardens damaged; loss to fruit crop and poultry.
Albuquerque, N. Mex.	23	3:15 p. m.	[1] 3		79,000	Heavy hail	Property damaged; small loss to crops.
Snow Hill, Md.	23	P. m.	[1] 1		500	Wind	Buildings unroofed; trees uprooted; 100 telephones disabled.
Roswell, N. Mex., vicinity of	23				4,000	Hail	Loss to cotton and fruit.
Berino and Chamberino, N. Mex., and vicinity.	24	1:30 p. m.	[1] 2		75,000	do	2,000 acres of cotton and all fruits, cantaloupes, sugar beets, and gardens destroyed.
Acala, Tex., vicinity of	24	P. m.			25,000	Heavy hail	500 acres of cotton destroyed.
Albuquerque, N. Mex.[2]	24					Rain and hail	Storm lasted 40 minutes, caused thousands of dollars' damage and about 100 families to abandon their homes.
Kingston, N. Y., and vicinity	25	2 p. m.	880			Hail	Considerable damage to windows and loss to fruit crop; path 10 miles long.
Bird City, Kans., vicinity of	25	2-4 p. m.	[1] 3		75,000	Heavy hail	Chief loss in wheat crop; path 9 miles long.
Oberlin, Kans., vicinity of	25	11 p. m.	3			do	Considerable crop loss; path 15 miles long.
Daviess and Sullivan Counties, Mo.	25	P. m.		1		Tornado	In Daviess County, 2 persons were injured and 9 houses, numerous barns, outbuildings, trees, and wires damaged. Amount of loss not available. Upon reaching the Grand River the tornado lifted and came down in Sullivan County, 5 miles south of Milan, where trees were uprooted, property damaged and telephones disabled. Damage in Sullivan County from $10,000 to $20,000.

See footnotes at end of table.

TABLE 4.—*Severe local storms, May 1937*—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Sioux, Plymouth, and Woodbury Counties, Iowa.	25–28				$44,500	Heavy rain and flood.	Property damaged.
Castle Rock, Colo.	26	1:15 p. m.	33	0	10,000	Tornado	Considerable property damaged.
Denison to Easton, Kans.	26	2:30–3 p. m.	[1] 12		15,000	Heavy hail	Chief damage in vicinity of Denison and Valley Falls. Loss in fruit and crops. Path 26 miles long.
Butler County, Kans.	26	3 p. m.			20,000	Wind	Chief damage to oil derricks in vicinity of Eldorado. Other damage reported.
Belle Plains and Riverdale, Kans., and vicinities.	26	4–6 p. m.	[1] 5		400,000	Heavy hail, wind, and rain.	West of Belle Plains crops were entirely destroyed and trees stripped of foliage. Many buildings and automobiles damaged. Path 10 miles long.
Baltimore, Md.	26	4:20 p. m.	[1] 2	0	75,000	Tornado and hail.	Small tornado over the central part of the city. Many poles blown down. Much damage to the north side of buildings; thousands of windows broken; trees stripped of small branches and greenhouses especially hard hit.
Hancock County, Iowa.	26	5:30 p. m.			10,000	Rain	Loss to corn and wheat crops; property damaged.
Olney, Md.	26	8:33 p. m.	100	0	5,000	Tornado	Houses unroofed or otherwise damaged; small buildings destroyed; telephone and power lines down and trees uprooted.
Dubois County, Ind.	26		1,320			Hail	Considerable loss to crops; property damaged.
Crawford to Iowa Counties, Iowa.	26		[1] 2	1	200,000	Tornado, hail, and rain.	Severe soil erosion because of excessive rain; hail washed into drifts 2 to 3 feet deep; loss to crops and gardens. Buildings destroyed. Path of storm 180 miles long.
Floyd County, Iowa.	26				12,000	Rain and flood	4 bridges washed away and 8 others damaged.
Eldorado, Kans., vicinity of.	26				20,000	Wind and rain	No details.
Pierre, S. Dak.	27	P. m.				Heavy hail	Considerable damage to C. C. C. camp buildings, automobile tops, and trees.
Hartsville and Stokes Bridge, S. C.	27				2,200	Electrical	Barn burned; several mules killed.
Knoxville, Tenn., vicinity of.	27				700	Thundersquall	2 silos and a few trees blown down.
Knoxville, Tenn., vicinity of.	28	12 noon				Thundersquall	Several barns and silos down; roofs and houses damaged.
Socorro, N. Mex., vicinity of.	28	3 p. m.		0		Tornado	No damage because of barren land.
Artesia, N. Mex.	28	4 p. m.	[1] 4		10,000	Hail	Loss to 2,000 acres of cotton.
Norfolk, Va., and vicinity	28	4:08–9:30 p. m.		1	5,000	Thundersquall, heavy rain.	Torrential rain and wind of 41 miles per hour with zero visibility. Several small boats upset. Buildings unroofed or damaged; tree uprooted and lowlying sections of the city flooded; electric lines disabled.
Forsyth, Mont., vicinity of.	28	6 p. m.	100	0	2,000	Tornado	Damage to farm buildings.
Montana, central and east portion.	28	P. m.				Wind and dust	Damage to crops, ranges, and property widespread and heavy. Winds of gale force raised huge clouds of dust that darkened skies and lowered visibility in numerous instances.
King William County, Va.	28				5,000	Thunderstorm and hail.	Hailstones large with much loss to wheat crop and poultry. Damage to buildings, gardens, and trees.
Chaska, Minn., and vicinity	29	A. m.			145,500	Rain and flood	Heavy to excessive rains washed out 5 wooden-spur track bridges, and long stretches of railroad tracks. Highways and lowlands inundated; basements flooded. 8 carloads of stored bricks washed away. Loss to prospective crops $500.
Roswell, N. Mex.	29–30				14,500	Rain and flood	Due to exceptional rains over a wide area in the mountains to the west, the Rio Hondo overflowed, flooding the city. By the morning of the 30th it had reached the eastern part of the city and the suburban district, known as Morningside. Inhabitants of Morningside were ordered to vacate at 4 a. m. By the morning of the 31st all streets were again passable to cars. Loss to truck crops. Estimate given only partial loss.
Crawford County, Iowa.	30	A. m.			4,000	Tornadic winds	Buildings on 5 farms damaged.
Elk River, Minn., and vicinity.	30	12:30 p. m.			2,000	Thundersquall	Trees, telephone and power lines down.
Clay County, Iowa.	30	5:30 p. m., and 7:30 p. m.			8,500	Tornadic winds	Property damage; loss to crops, $500.
Clayton and Roy, N. Mex., and vicinities.	31	3:30 p. m.	[1] 5		20,000	Hail	Property damaged. Considerable damage at Roy, but no estimate given.
La Junta, Colo.	31					Heavy rain, hail, and flood.	Commercial district inundated; buildings flooded. Property damage estimated in thousands of dollars. Flood swept through nearby fields causing complete ruin to crops in several districts.
Lincoln, N. Mex., vicinity of.	31				20,000	Hail	Property damaged.
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Newport, Ark., and vicinity	23	4 p. m.			$15,000	Hail	Damage to property and gardens; path 4 miles long.
Webster County, Iowa.	23	6 p. m.			14,000	Squall	No details.
Coal Hill to Harmony, Ark.	23	7 p. m.	880		4,000	Hail	Loss to crops, $2,000; property damage, $2,000; path 12 miles long.
Jefferson, Iowa.	23	do		0	4,000	Tornado	No details.
Nowata, Okla.	23	do	[1] 4		1,500	Heavy hail	Property damaged; loss to gardens.
South portion of Montgomery County, Ark.	23	7–7:45 p. m.				Hail	Considerable damage to gardens.
Fort Dodge, Iowa.	23	8 p. m.		0	10,000	Tornado	No details.
Adams and Adair Counties, Iowa.	23	8–9 p. m.			2,000	Wind and hail	High winds damaged buildings.
Boone County, Iowa.	23	9 p. m.			1,100	Tornadic winds	Funnel cloud observed.
Benton, Ark.	23	9:15 p. m.	50–75	2	40,000	Tornado	30 persons injured, 5 seriously; property damaged; path 2 miles long.
Lake Mills, Iowa.	23	10:30 p. m.			3,000	Squall	No details.
Wright County, Iowa.	24	8 p. m.			4,100	do	Property damaged.
Hancock County, Iowa.	24	10 p. m.			16,000	Wind and hail	No details.
Belmond, Iowa.	24	P. m.			25,000	Wind	Property damaged.
Iowa, western third of State	24–25			1	60,000	Snow, sleet, and wind.	Damage along the western boundary of the State and to a lesser extent in all the two western tiers of counties. Snowdrifts blockaded highways; small towns isolated and hundreds of motorists marooned. Much damage to telephone system; trees broken; windmills and old buildings wrecked.
Green, Webster, Hamilton, and Wright Counties, Iowa.	29	7–9 p. m.		0	2,000	Tornado	No details.
Dumas (near) Ark.	29				1,000	Electrical	Barn destroyed.

[1] Miles instead of yards.

[2] From press reports.

Chart I. Departure (°F.) of the Mean Temperature from the Normal, May 1937

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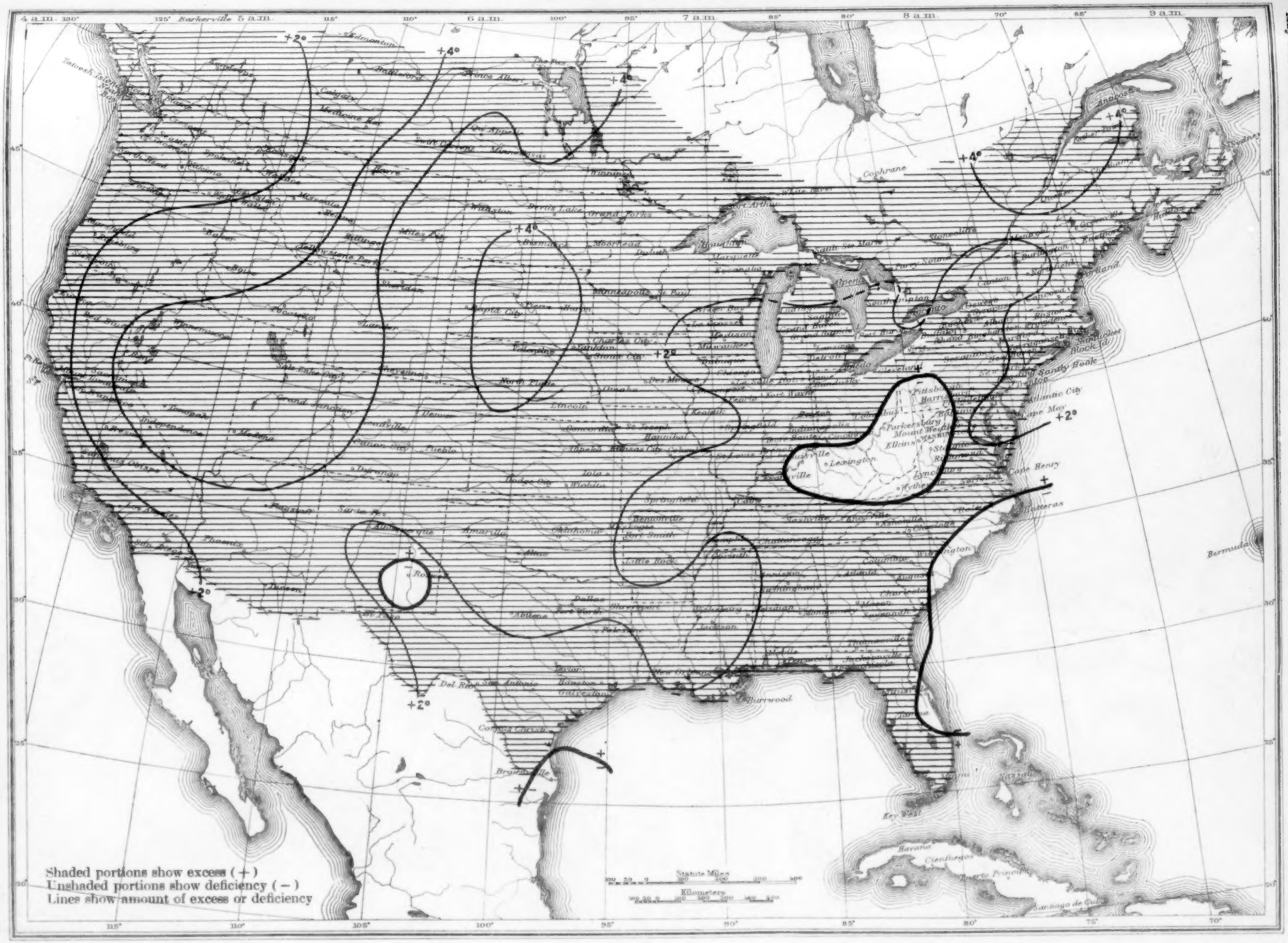
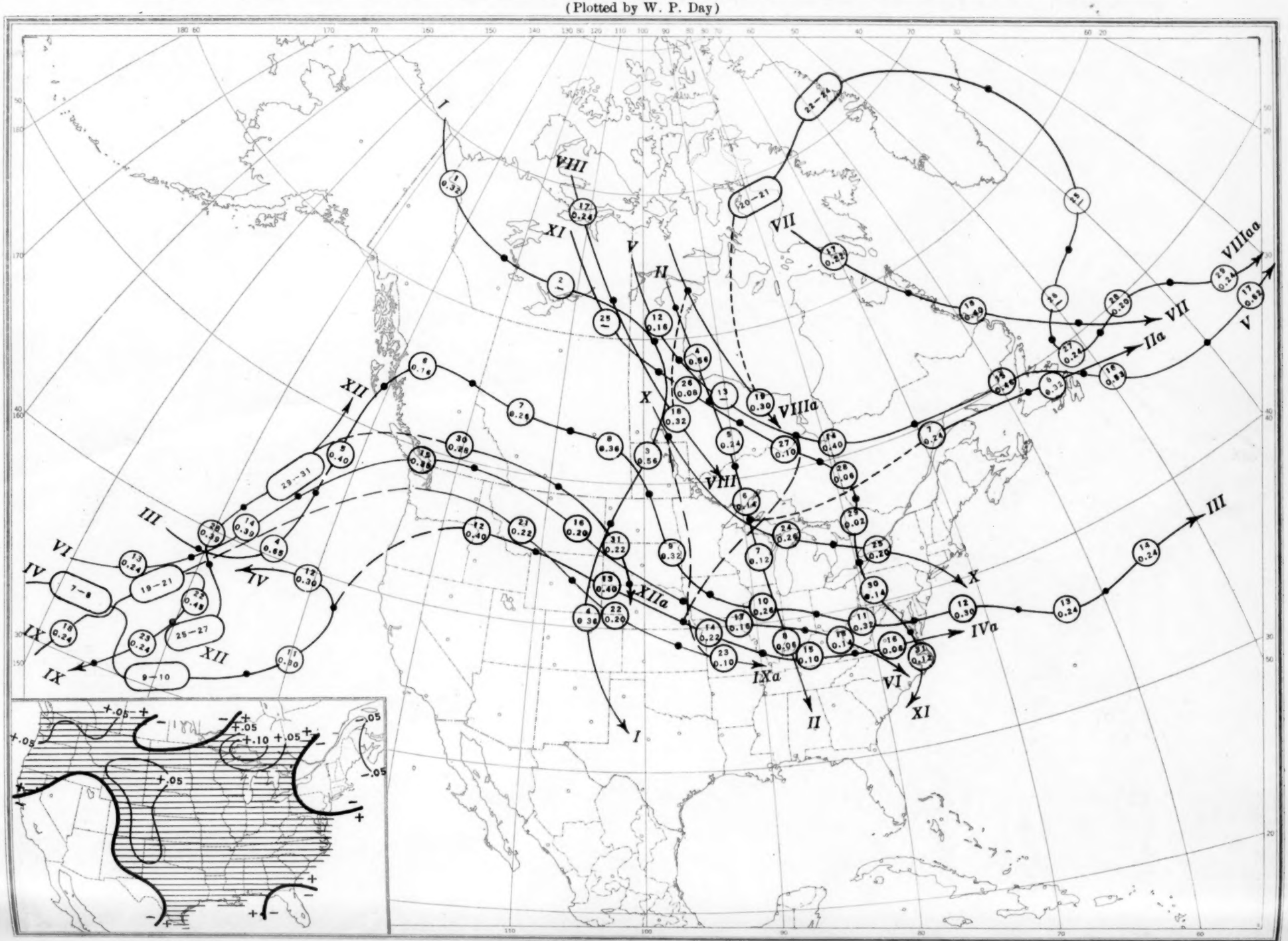


Chart II. Tracks of Centers of Anticyclones, May 1937. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by W. P. Day)



Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

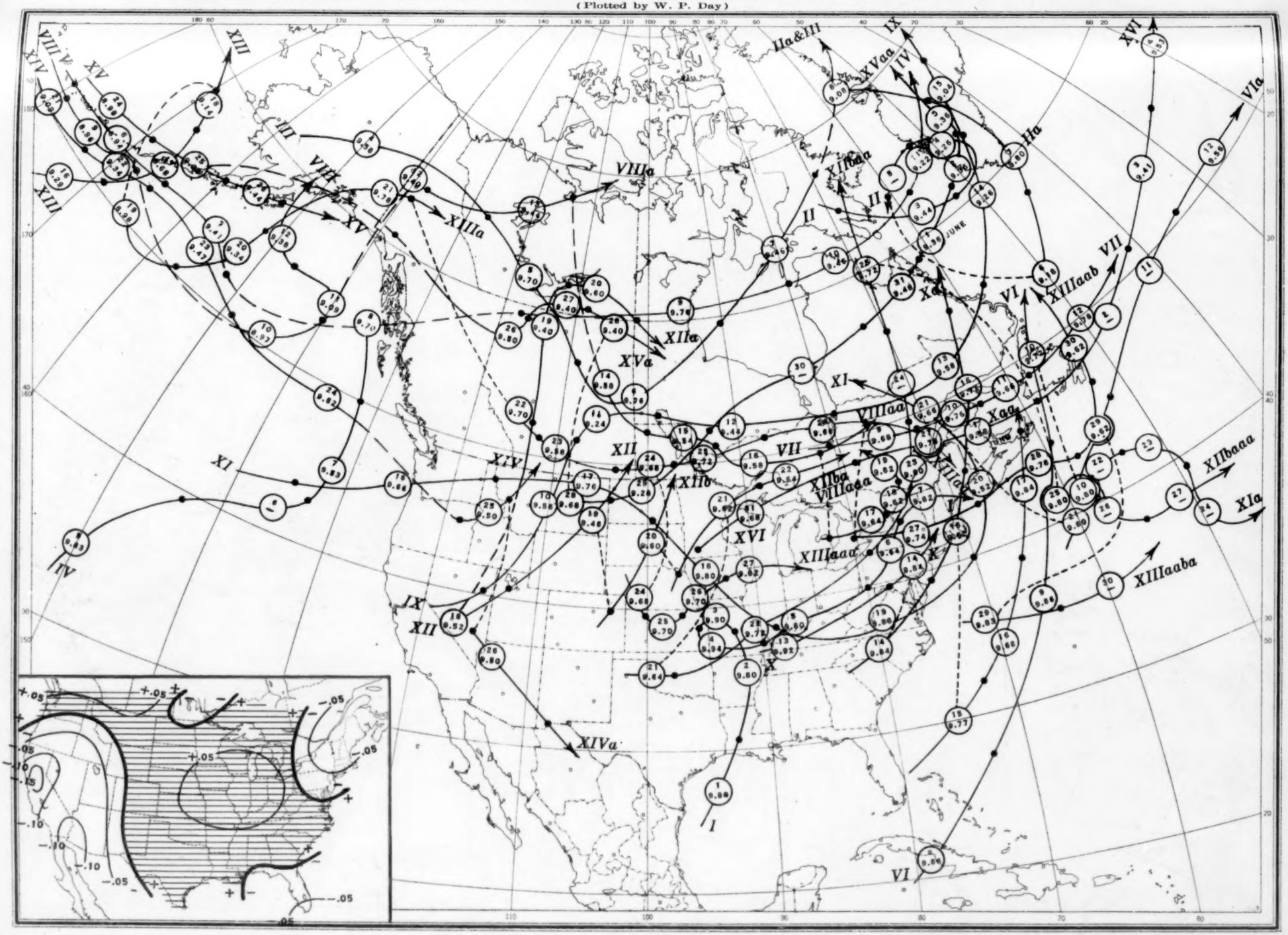
Chart III. Tracks of Centers of Cyclones, May 1937. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by W. P. Day)

Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, May 1937. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by W. P. Day)



Circle indicates position of cyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 7:30 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, May 1937

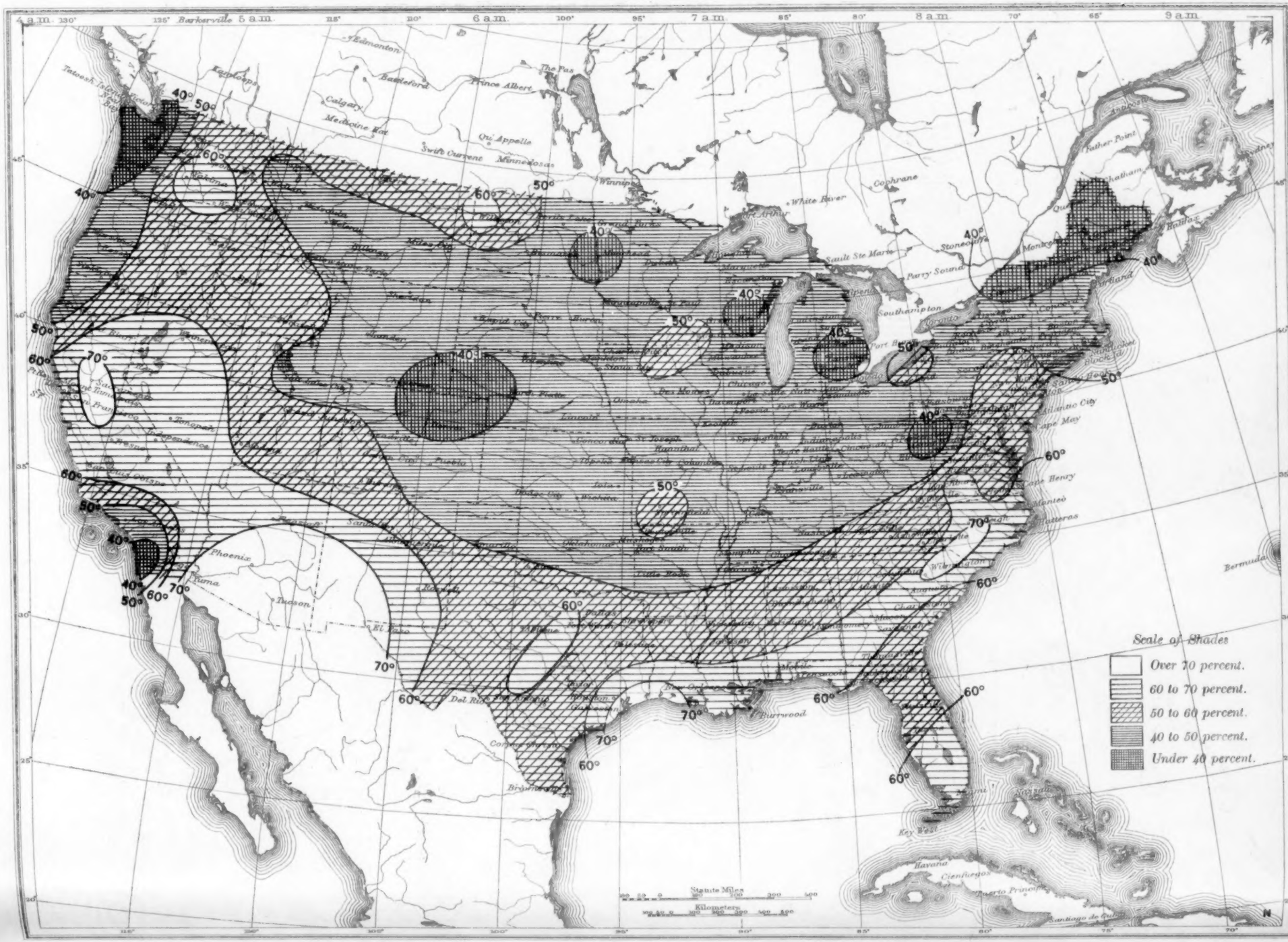


Chart V. Total Precipitation, Inches, May 1937. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, May 1937. (Inset) Departure of Precipitation from Normal

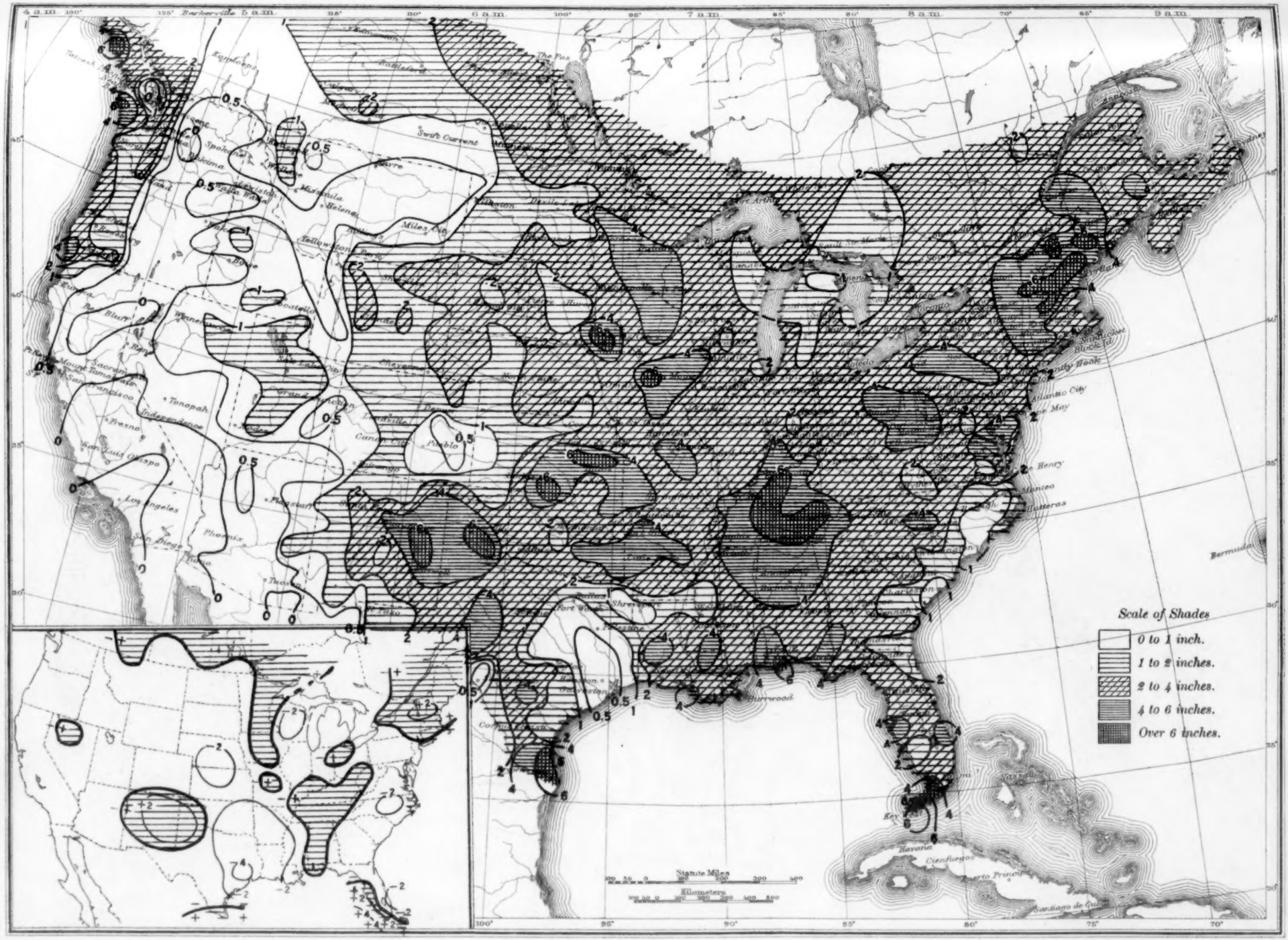


Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, May 1937

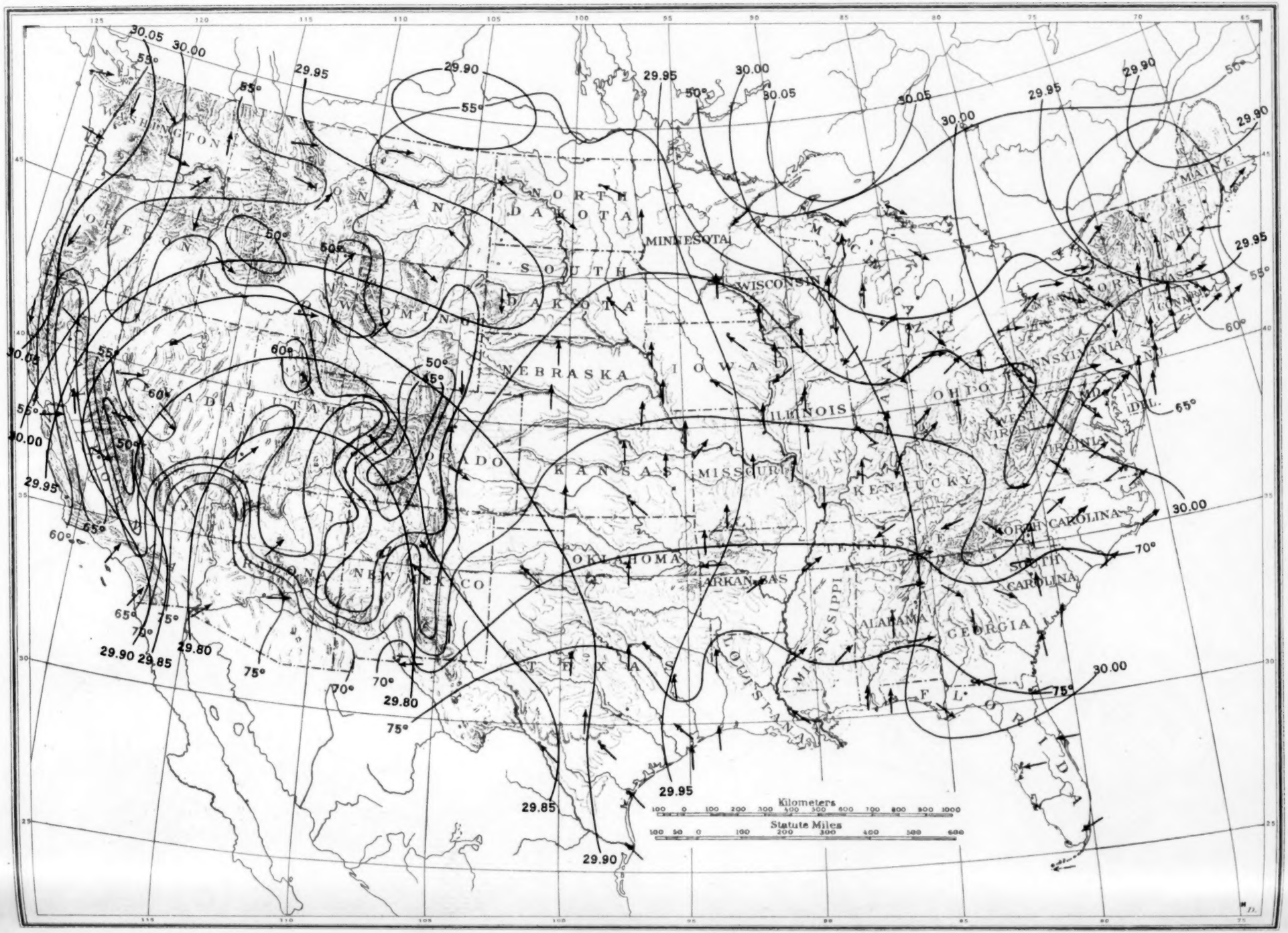


Chart VII. Wind Roses for Selected Stations, May 1937

(Plotted by W. W. Reed.)

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